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[ENGINEERING.]

MISCELLANEOUS NOTES.

ACTION OF LIGHT ON SILVER RESISTANCES.

The researches of Professor Bell, M. Mercadier, and others have shown that selenium is not the only substance which is affected in its electric resistance by light; and the recent experiments of M. Bœrnstein would appear to demonstrate that silver should also be added to the category. He took two plates of glass chemically covered with a thin coat of silver. The ends of the plates were electrotyped with copper and used to connect the two other branches of a Wheatstone "bridge." When a balance had been obtained one of the films of silver was lit by the ray from a spirit lamp colored with sodium. The influence of the light was to increase the resistance of the silver, and that the maximum resistance was only attained at the end of a certain time. It would be more satisfactory to feel sure that the increase of resistance was not due to heating by the rays.

THE NEW FAURE ACCUMULATOR.

After trying lead plates covered with minium and sheathed in flannel, then rolled into a spiral form for the Faure accumulator, recourse was had to square plates standing side by side. M. Emile Reynier, however, electrician to the Force et Lumière Company, has modified the battery by returning to the original shape of a spiral roll for the plates, and sheathing them in a sort of linen serge instead of flannel, after they have received their coat of minium. He also incloses the plates in a glass vessel instead of a wooden trough, principally because the electrician can more easily see if there is any discharge of gas bubbles from the plates. In charging, the appearance of these bubbles, if the cell is a good one, indicates that the supply of current ought to be suspended, because the cell is full. Should the bubbles appear before the charging is complete the cell is considered faulty. The reason of this is that the oxygen liberated on the electro-positive plate ought to be entirely used in oxidizing the minium, and it is only when that oxidation is complete that the gas should rise from the plate.

A NEW MAGNETO-ELECTRIC EXPLODER.

M. Marcel Deprez, the eminent French electrician, has constructed a new magneto-electric machine for exploding mines and torpedoes which possesses several points of interest. Instead of passing the instantaneous current induced in the coiled armature suddenly snatched from the poles of the magnet, directly through the wires to the fuse in the mine, he passes it through the primary circuit of an induction coil, and the secondary spark from this coil is sent along the wires to explode the mine. This change neces-

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PAGE WELCOMING SHALLOW AND EVANS   M. W. OF W. ACT I. SC. I.

SLENDER AND ANNE PAGE

"WIFE BID THESE GENTLEMEN WELCOME"   M. W. OF W. ACT I. SC. I.

SUGGESTIONS IN DECORATIVE ART.—STAINED GLASS DINING ROOM WINDOW.—THE MERRY WIVES OF WINDSOR.

sitates some modification in the exploder as ordinarily made. For instance, the wire of the armature coil ought to be thick so as to give small resistance, and the induced current due to the withdrawal of the armature should be broken when at its maximum strength in order that the rupture may induce a maximum current in the secondary circuit of the induction coil. M. Deprez also found that ordinarily the armatures of exploders contained too much iron, and he has therefore reduced this feature. In the new exploder of M. Deprez, the armature consists of a coil of stout wire wound on a core of sheet iron which is carried by two crank levers mounted on the same axle. By striking a small pedal attached to the other arms of these levers the armature is suddenly jerked away from the poles of the horseshoe permanent magnet it rests against, and the spark generated flows into the primary of the induction coil. The interrupter of the latter is to be adjusted so as to give the longest spark from the secondary.

ON CEMENT.

Some useful results obtained by German experimenters on the behavior of cement under different conditions are given in the current volume of *Dingler's Polytechnisches Journal*, p. 1088. According to Herr Schumann, all cements, if allowed to harden in water, increase in volume, the largest increase taking place during the first period of settling. The increase is larger with newly-prepared cement, smaller with finely-ground cement. The addition of gypsum also increases it, while the admixture of sand diminishes it. Building stones were likewise found by Schumann to expand in water, and contract again on being dried in air. The greater the porosity of the stone the smaller is the increase in volume. These changes are, however, in his opinion, too slight to interfere with present practice in building operations. With regard to the behavior of concrete under heat, Herr Feege finds that it can be exposed to a temperature of 130 deg to 150 deg. Cent. without injuring its supporting strength. At higher temperatures, however, it loses firmness and becomes brittle. An important fact bearing on the preparation of mortar was elicited by Schumann's experiments. He found that all cements, whether used as fine or coarse powder, or burnt slightly or strongly, give the same yield of mortar, and therefore recommends weighing the quantity of cement instead of measuring it as is usually the case We should add that Herr Delbrück objects to prepare concrete under water, and holds that all excavations should be kept as dry as possible during the actual process of concreting. Herren Büsing and Dyckeshoff, on the other hand, strongly recommend concreting in water, and cite many large undertakings in which it has been successfully effected.

SHIPBUILDING.

The tonnage statements of the vessels that have been launched last year show the marked progress that has been made in shipbuilding at many of the chief ports, and the great competition that has been known among some of the chief shipbuilders. The first place is taken by the Palmer Shipbuilding Company, of Jarrow, which has launched over 50,000 tons of shipping. But the second position on this occasion seems to have passed to Barrow-in-Furness by a few tons; the third place in the rank of producing firms being taken by Messrs. W. Gray & Co., of West Hartlepool. The largeness of the contributions to the total are remarkable, and the extent to which the north-eastern district—from Blyth to Whitby—has launched vessels, is also very notable. But it will be probably found when the figures for that district are analyzed, that there has been in the past year a reduction in the tonnage of steel steamers built, as compared with the previous year. The demand for iron vessels has been so large that firms that had previously entered into the building of steel vessels have laid it aside. Another fact that strikes the inquirer is, that the vessels built are now such as consume a larger quantity of iron than formerly—many parts of the vessels that were built of wood down to a short time ago, have now been generally made of iron. There is a distinct tendency, moreover, to increase the average tonnage of the vessels built But on all points the year 1882 opens with prospects for the shipbuilders that are brighter than were those of its predecessor. There is on all hands fullness of work, and in some instances orders that will last through the whole of the year, so that, failing any unexpected check, the tonnage built in 1882 should be above that of the past year.

THE POTENTIALS OF ELECTRIC SPARKS.

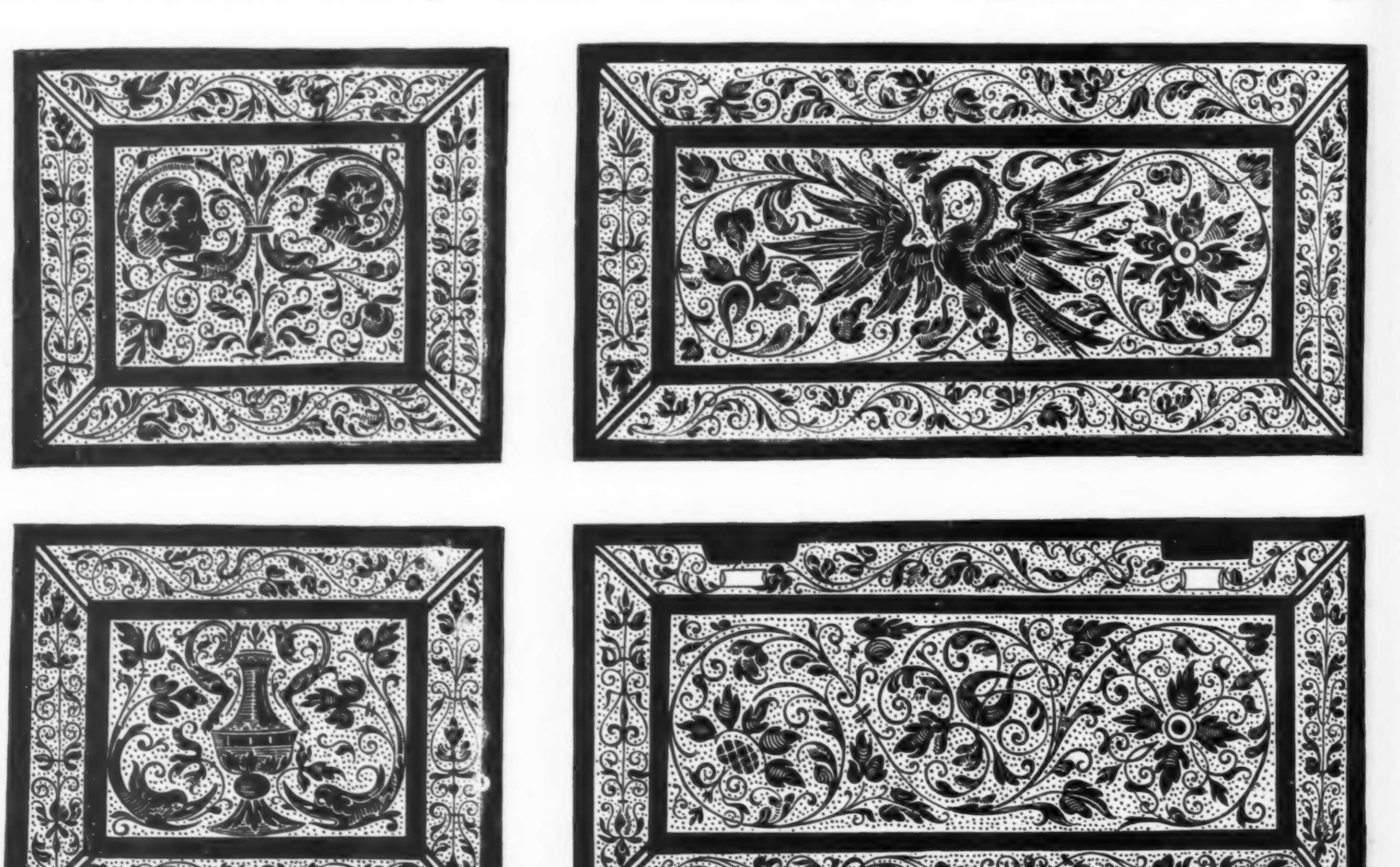
Sir William Thomson has made a great many experiments on the difference of potentials corresponding to electric sparks of different length across the air; but a recent investigation of M. J. B. Baille on the same subject, but with somewhat longer sparks, furnishes results which are not quite in agreement with those of Sir William. The potentials of the latter physicist corresponding to sparks of a certain length are slightly less than those obtained by M. Baille for the same length of spark, and the discrepancy is attributed by M. Baille to Sir William Thomson having used a conductor which was constantly discharged by a continuous series of sparks, so that the potential was continually varying very rapidly, and only an intermediate value, somewhere between the maximum and minimum, could be obtained. M. Baille, though employing an absolute electrometer to measure the potentials, as did Sir William Thomson, took care to keep the difference of potentials constant during the measurements, by using a condenser that only gave sparks at long intervals. The potential was thus a maximum slowly attained, and the attraction also became a maximum at the moment of sparking. His results show generally that the potential of an electrified plate increases almost regularly with the sparking distance. The electric densities corresponding to different sparks decrease at first slowly and soon arrive at a constant value as is already known. The pressure exercised by the electricity on the air at the sparking moment for a distance of one centimeter is only one two-thousandth of the atmospheric pressure. We may add that the difference of potentials, as found by M. Baille, for a spark of 0·0025 centimeter is 1·90, that for 1 centimeter 14·67, that for 5 centimeters is 54·47, and that for 10 centimeters is 105·50 units.

THE GULF STREAM AND THE PANAMA CANAL.

Professor James Geikie, F.R.S., in a recent communication to the *British Trade Journal*, discusses the influence of the Gulf Stream in ameliorating the climate of Western Europe, and the effect of its withdrawal from these regions According to Dr. Croll, the eminent geologist, the total quantity of heat conveyed by this ocean current is equal to that of a stream of water fifty miles broad and 1,000 feet deep, having a mean temperature of 65 deg. Fahr., and flowing at the rate of four miles an hour. This represents a total quantity of heat transferred from the tropics to the north, equivalent to 154,959,300,000,000,000,000 foot-pounds per diem. Even if this estimate be reduced one-half, the stoppage of the Gulf Stream would deprive the Atlantic of a quantity of heat equal to one-fourth of all that received directly from the sun in that area. The warming influence of the Gulf Stream is evident from the mean temperatures of spots on the same parallel of north latitude in Europe and America. Thus at Bordeaux in N. lat. 44 deg. 50 min. the mean winter temperature is + 41 deg. Fahr., and the mean summer temperature is + 69·1 deg. Fahr.; whereas at Halifax (Nova Scotia) the corresponding temperatures are + 22·6 and + 63·5. Again, in Scotland the winter and summer means are 38·5 deg. and 56·5 deg. whereas at Hebron in Labrador they are respectively —5·1 deg. and + 46·1 deg. In the event of the Gulf Stream being stopped, the polar currents flowing south would occupy a great part of the Atlantic, and the westerly winds, instead of being warm and moist, as they are now, would become cold and ungenial, and a large part of our islands together with Scandinavia, would become uninhabitable by civilized man. Within the human epoch Northern Europe has experienced both a colder and a warmer period than that now prevailing. The arctic fox, glutton, and reindeer once prowled in the forests of Northern France; and, on the other hand, the figtree and canary laurel once flourished in the vicinity of Paris, while elephants, lions, and tigers ranged in the forests of the Thames. These climatic changes were probably due, Mr. Geikie thinks, to some alteration of the Gulf Stream; although no trace of any submergence of the Isthmus of Darien has been observed as yet The depth of submergence of this neck of land would require to be not less than 800 feet or 1,000 feet in order to divert the whole of the Gulf Stream into the Pacific; and therefore, the construction of the Panama Canal "will have as much effect upon the Gulf Stream and the climate of north western Europe as the emptying of a teapotful of boiling water into the Arctic Ocean would have in raising the annual temperature in Greenland."

NICKEL-PLATING.

The application of the dynamo-electric current to galvanoplasty has greatly favored the introduction of nickel-plating on a large scale; for it is by this current that the pure silvery color of the metal and a regular deposit are best obtained. A flourishing business in nickel-plating has now grown up in England, thanks in great measure to Mr. William Elmore, of Blackfriars Road, S. E., who was, we believe, the first to bring the American plan of dynamo-electric nickel plating to this country. At first the Weston dynamo-electric machine was employed for this purpose by Mr. Elmore, but he has now introduced a machine bearing his own name, which has several advantages over its forerunner. In the "Elmore" machine, for example, the mercury commutator of the Weston, together with the cooling stream of water, is abolished. According to some experiments made by the Nickel Plating Company the quantity of metal deposited in a given time by the Elmore machine is several times that deposited by the Weston. To give an idea of the power of the new machine we may state that one of "C" type will supply electricity to deposit an ample coating on two or three large working tanks in about three hours, whereas a considerable number of powerful batteries would not accomplish the same in less than eight or ten hours. The machine is kept going at a rate of 850 turns per minute by one horse power, and the current produced is equal to that from 100 small cells of three gallons each. Moreover, the machine is constructed to suit all kinds of electrotyping, gilding, silvering, bronzing, coppering, nickeling, brassing, and tinning. Electro-tinning is a new process which we owe to Mr. Elmore, and by which sheet-iron plates are coated with tin, without the drawback of using acids, which in the old process cause the plates to "sweat." Cast iron, steel, and any other kind of metal work can be electroplated by the dynamo-electric current with great finish, and Mr.



ORNAMENTS IN ETCHING OF AN IRON CASKET, IN THE BAVARIAN NATIONAL MUSEUM IN MUNICH; SIXTEENTH CENTURY.—*From the Workshop.*

Elmore in a recently published "catalogue" gives a very instructive and practical sketch of the methods used for these purposes. At the Art Metal Depositing Works of the Electrolytic Company Charlotte Street, Blackfriars, there are tanks being fitted up by Mr. Elmore which are capable of holding several thousand gallons of solution each; as the "C" machine can deposit 500 lb. of metal per diem, the company will be able to coat boiler tubes, lamp-posts, screw propellers, and metal work of great size. The details of the largest marine engines, for example, can be nickel-plated with ease, and two pieces of ordnance with their carriages have, we understand, been sent from Chatham to Mr. Elmore to be plated.

A CURIOUS ACTINIC PHENOMENON.

A very curious phenomenon that puzzled at least one chemist a good deal, has quite recently found its explanation. More than a year ago, Mr. Thos. Griffiths noticed a gate-post with an uncommonly eccentric new white pigment. The gate-post, which had been painted with so-called zinc-white, appeared black all day, gray in the twilight, when most other colors would be more or less gray, white during the night, and changed into black again pretty quickly after sunrise. Mr. T. L. Phipson's attention was drawn to this peculiar zinc-white; nearly a year, however, elapsed before he thought he could publish the fact and its explanation at the same time. Mr. Phipson, Ph.D., was inclined to make the barium sulphate, used for precipitating the zinc in question, responsible, but then he found that a sheet of ordinary window-glass was quite sufficient to spoil this peculiar property of the pigment, and this certainly did not make the case very much clearer. Mr. Crawley, who further studied the matter, gained the experience that sometimes the supposed white would not turn out white at all, but gray from the very first; that was the fault of small quantities of iron however. Still, he was unable to agree with Mr. Phipson about certain combinations, the coexistence of which the latter anticipated. The real defaulter has after all been entrapped by Dr. Phipson. It is a new metal, named actinium in honor of its actinic eccentricities. The sulphide of this metal is a white body that under the influence of the sun's rays is quickly reduced to a brown and finally black compound, which, if exposed to the air in the dark, reoxidizes to the original white body. Why a glass sheet would interfere with this change of color is now clear. We have to deal with a reduction process, possible only when light is present. If we could, therefore, supply a reducing agent, such as pyrogallol for instance, and admit the light through a glass cover, the change into black might take place, and has indeed been produced by Mr. Crawley. The new metal in general resembles zinc. In the pigment employed both metals were contained as sulphides, the quantity of the actinium sulphide amounting to as much as four per cent. Actinium is probably, like gallium and indium, one of the companions of zinc in certain ores. As yet we must consider it as very rare. A good many of the common paints will darken under various conditions; lead white, for instance, very similar to zinc white, may turn actually black, as is well known. Such a peculiar opposition to light, however, as exhibited by actinium sulphide—according to Mr. Phipson, none of the other compounds of actinum as yet showed a similar sensitiveness—to appear light in the dark and dark in the light, would scarcely have escaped notice. It remains, of course, possible that the new metal occurs in a good many ores, only in quantities too small to develop the peculiar phenomenon that led to its discovery.

FRENCH RAILWAY VIADUCTS.

THE ALTIER VIADUCT.—This structure (Figs. 1 and 2), which was erected on the line from Brioude to Alais for crossing the Altier River at about 2 kilometers from Villefort (Lozère), presents in its plan a curve of 400 meters radius, and carries a single track with a gradient of 0·025 of a meter to the meter. The foundations of the piers rest on rock; and the maximum height of the viaduct, from the lower level of the foundations to the level of the rails, is 73·33 meters, while the length, through the axis, is 243 meters.

The work consists of 11 semicircular arches of 16 meters span, and of 4·50 meters width between the heads. The center piers are connected below by semicylindrical arches of 3 meters width between the heads, supporting a paved roadway. The piers, which have arched openings at the level of the roadway so as to give a passage 2 meters in width and 4 meters in height under the keystone, are 4 meters in thickness at the springers. From this point up to the crown of the lower arches they have a batter of 3 to 100 on the lateral faces, and 6 to 100 on the head faces; below this, the batter is respectively 4 and 7 to 100. Buttresses, 2 meters in width and projecting 0·5 of a meter between the level of the roadway and that of the springers, are established against the outer faces of the piers. These, from the springers up to the crown of the lower arches, have a batter of 2 to 100 on the lateral faces, and 9 to 100 on the head faces. Finally, beneath the crown of the lower arches the batter has been carried respectively to 2½ and 10 to 100. The pressure of the masonry per square centimeter is, at a maximum, 7·7 kilogrammes. The vaults are cylindrical, so that a horizontal section of the piers presents the form of a trapezoid. The coping of the viaduct is 0·45 of a meter in thickness and supports a cast-iron balustrade one meter in height, which is sealed into blocks of dressed stone established on the buttresses of the piers. The piers and buttresses are built up on a foundation bed of quartzose schist, which was cleared away to the solid rock and then worked into horizontal steps. The facings are of triassic sandstone brought from a distance of 8 kilometers, and supporting pressures of from 250 to 350 kilogrammes per square centimeter. The facings in view are of rubble, while the angles of the piers and buttresses and the platbands of the vaults are of dressed stone. The quartzose schist rubble necessary for the construction of the interior of the work was found in quarries opened at the very base of the structure. The sand, which was extracted from a pit situated about one kilometer distant, was led to the work by an inclined plane. The construction of the viaduct lasted two years. On removal of the centerings the subsidence varied between 0·006 and 0·008 of a meter.

Each center, composed of four frames, cubed 35·28 meters. The materials were hoisted by means of two steam cranes 35 meters in height rolling horizontally along a service bridge built 36 meters above low-water mark. The total cubage of the masonry is 26,804 meters, 425 cubic meters of which is dressed ashlar. The surface of the rubble-work is 12 931 square meters, and the surface of elevation of the work between the ground and rails (solid parts and spaces) is 9,530 square meters. The total expense was 845,248 francs, or 88 francs per superficial meter of elevation and 27 francs per cubic meter of masonry.

THE CIZE VIADUCT.—This viaduct (Figs. 3 and 4), constructed on the line from Bourg to Cluse for crossing the river Ain, is 268·9 meters in length and of a maximum height of 55 meters above the river.

The work, which is entirely of masonry, is formed of a row of 11 semicircular arches superposed on another row of seven in number. The upper arches are of 20 meters span

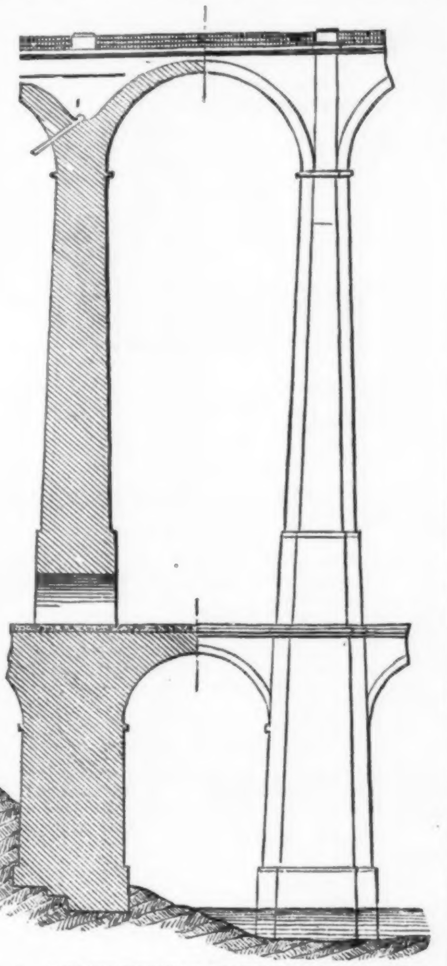


FIG. 1.—LONGITUDINAL ELEVATION AND SECTION OF TWO CONSECUTIVE PIERS.

each, with springers all on the same level. The lower row of arches are depressed, and form flying buttresses. The width of the upper arches between the heads is 4·6 meters. They are carried on piers strengthened by rectangular buttresses, of a uniform width of 2·4 meters, and having a batter of 0·05 of a meter per meter in a direction perpendicular to the railway and of 0·02 of a meter per meter in the longitudinal direction of the work. The width of the lower arches is 4 meters between the heads. They are capped by a paved roadway, at the level of which the piers contain semicircular apertures 2 meters in width. The roadway is 20·9 meters above the bed of the river. The thickness of each of the piers at the springers of the arches is 2·8 meters. The vaults are one meter in thickness at the keystone. To ease the haunches of the arches there were constructed over piers longitudinal vaults hidden by the tympanums. The butments are hollowed out in the form of vaults of 3 meters span, each hidden by the outer facings. Finally, the viaduct is covered with a layer of mortar 0·03 of a meter in thickness. Water is led off through leaders inserted in the haunches of the arches. The structure is capped with a coping of dressed stone with modillions projecting 0·25 of a meter, and supports an openwork parapet. The lower arches are likewise surmounted by a parapet.

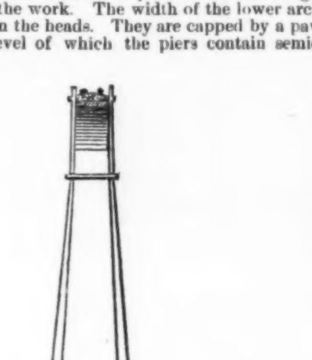


FIG. 2.—TRANSVERSE SECTION THROUGH THE AXIS OF AN ARCH.

The river bottom consisted of hard-pan, with an intermingling of large water-worn flint-stones, the piers were built on a foundation of beton laid within an inclosure of piles and planks, and resting on a base composed of large round stones reaching about 2·5 meters above the level of the ground. The other piers rest on rock at a mean depth of 2 meters under ground. The river piers are surrounded at their base with a heavy mass of rockwork. The viaduct is constructed of rubble laid in regular courses, the interior consisting of rubble filling. The coping and parapets are of dressed stone.

The total cubage of the masonry is 13,793, divided up as follows:

Foundation masonry		817 cub. meters.	
Masonry of the Elevation.	Rubble facing	4,674	"
	Filling	7,994	"
	Dressed stone	306	"
Total		13,791 c.m.	

The vertical superficies of the work (solids and open spaces) is, 9,830 square meters, 2,908 square meters of which is solid and 6,922 square meters open spaces—the measurements being taken from above the foundations up to the coping. The pressures per square centimeter are: 6·34 kilogrammes at the upper springers; 10·75 kilogrammes at the level of the roadway of the lower arches; and 10·15 kilogrammes at the level of the upper part of the foundations.

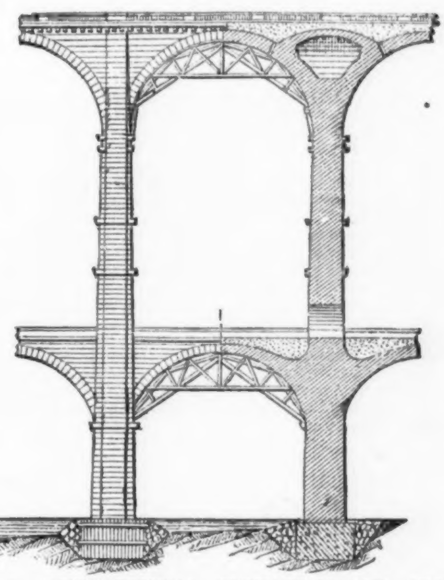


FIG. 3.—LONGITUDINAL ELEVATION AND SECTION OF TWO CONSECUTIVE PIERS.

The expenses of construction were 308,948.75 francs, corresponding to 38·42 francs per superficial meter of the total elevation, and to 20·55 francs per cubic meter of masonry. In this sum the foundations figure at 34,001.24 francs; the rockwork at 8,300 francs; and the remainder of the work at 266,647.54 francs.

The process of building the viaduct was as follows: There was constructed in the direction of the axis of the work one American service-bridge carrying a track 0·6 of a meter wide for transporting the materials. The foot-way of the bridge contained over each pier a trap through which was lowered the mortar brought by cars with a movable bottom. The other materials were brought on trucks running on the tracks which connected the work with the place of storage, and were lowered to the work in box wheelbarrows by means of a winch. The service-bridge was raised in measure as the work progressed in height. The centers which served for the construction of the vaults consisted of four frames resting on corbels (Fig. 3). There was a set of six centers,

FIG. 4.—TRANSVERSE SECTION THROUGH THE AXIS OF AN ARCH.

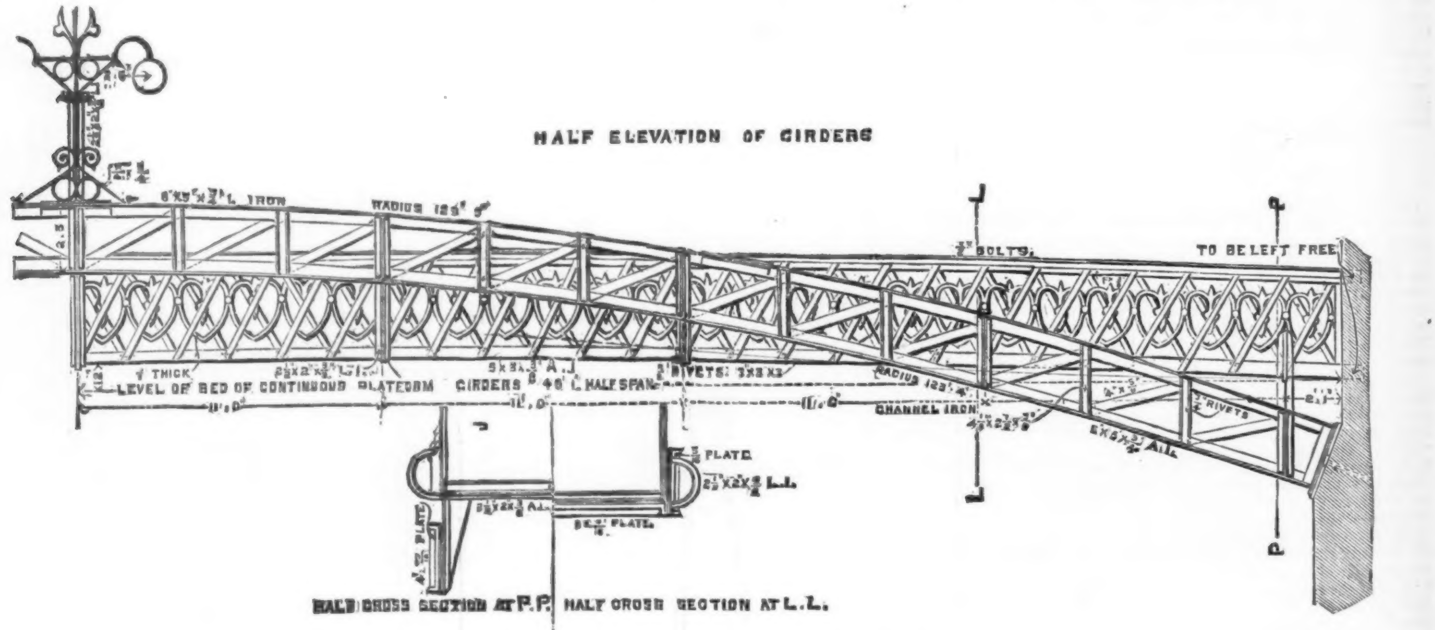
and when one vault was finished the center was taken out and used for the construction of another. The apparatus for removing the centers consisted of an iron cylinder filled to within a third of its length with sand. In the interior of this there was a solid wooden cylinder which descended in measure as the sand ran out at the base. This apparatus was placed between two rows of beams.—*Annales des Travaux Publics.*

WELLAND RIVER FOOT BRIDGE.

In July, 1880, the valley of the river Welland was visited by a storm which caused a flood higher than had been known for two hundred years. At Stamford, Eng., the river rose 10 ft. higher than its ordinary level, and washed away an iron foot bridge of 80 ft. span erected as a memorial to the late Prince Albert, depositing the whole of the superstructure in the bed of the river some distance below its proper position. The bridge was a very light arched structure and about 5 ft. 6 in. wide. Although the water did not rise above the platform of the bridge, the hay and other matter brought down filled up the spandrels of the arch, and it is supposed some large object coming down with the flood finished the work which the accumulation of *débris* had prepared.

Considerable discussion took place in the town council as to whether the bridge should be replaced by a foot bridge or a road traffic bridge, and a report with drawings was obtained from Mr. J. B. Everard, C. E., of Leicester, upon the subject. It was finally decided, in consequence of the considerable cost of a road bridge and the necessary approaches, to rebuild the foot bridge, and this has now been done from the designs and under the superintendence of Mr. Everard, and we give some illustrations of the work herewith. These illustrations are complete in themselves, and require no explanation.

The bridge and abutments have been entirely rebuilt, it being considered advisable to increase the span and to widen the structure. In view of the disaster which befell the first bridge, it was considered advisable to keep the whole structure well above the water; and as the council objected to raising the level of the platform, a simple arch was out of the question; but as a straight girder bridge of the necessary depth would have had an unsightly appearance, particularly where the girders joined the abutments, a compromise was effected by putting in arched girders at a high level and carrying the platform between, and the result justifies the method adopted. The construction of the bridge will be readily understood from the illustrations, the whole of the weight being taken by the arched ribs, which are strongly braced together, partly under the platform and partly by the central cross brace which carries the gas lamps. The clear span is 90 ft. and the width of the platform 8 ft. The abutments are largely composed of concrete. The platform is cement concrete covered with Val de Travers asphalt, the concrete inclosing the cross rolled iron joists, but having no plates underneath.



FOOT BRIDGE OVER THE RIVER WELLAND.

The cost of the structure has been between £700 and £800; the contractor for the builders' work, Mr. C. Hinson, of Stamford; and for the iron work, Messrs. Dawson & Nunneley, of Hunslet, near Leeds.—*The Engineer.*

CONSTRUCTION OF A WATER RESERVOIR IN BETON.

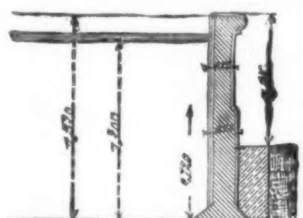
We give in the accompanying figure a transverse section of a reservoir of beton cement, the plan of which is in the form of a regular octagon, with an interval diameter of 5·33 meters. The thickness of the walls was calculated by means of the following formula: $W = 0{\cdot}0005 \frac{h}{f} d$, in which h represents the height of the water, d the diameter of the circle circumscribed around the basal polygon, and f the coefficient of the beton's resistance.

In this formula, on making h = 120 cm.; d = 533 cm.; and f = 2 k. per centimeter, we find that

$$W = 0{\cdot}0005 \times \frac{120}{2} \times 533 = 16 \text{ centimeters.}$$

The beton was composed of one part Portland cement, two parts of fine sand, and three parts of broken stones. This was poured and rammed into a mould with a thickness of fourteen centimeters for the socle and of twelve centimeters for the wall above it. The exterior of the walls was covered with a layer composed of one part of cement to one part of sand, and having a thickness of five millimeters. The internal surface of the walls in contact with the water was covered with a layer of the same composition, but having a thickness of fifteen millimeters. This covering was not sufficient to make the reservoir water-tight, and it therefore became necessary to add a second layer of ten centimeters in thickness. At the end of two years' service the reservoir became perfectly tight.

A second reservoir, established under the same conditions as the foregoing, cracked externally without there resulting any inconvenience as regards water-tightness. The accident was attributed to the fact that the reservoir was constructed during very hot weather and in the full rays of the sun.



The thicknesses to be given to the walls of reservoirs such as we have just described may be calculated by the following empirical formulas:

$$W = 0{\cdot}09 + 0{\cdot}0125 \text{ D.H.} \quad (1)$$
$$W = 0{\cdot}09 + 0{\cdot}0094 \text{ D.H.} \quad (2)$$

in which W represents the thickness sought, D the maximum diameter of the reservoir, and H the height of the water in the latter. The dimensions are expressed in meters.

Formula 1 serves for calculating the thickness of the socle of the vertical wall, and formula 2 the thickness of the wall above the socle.

The beton is supposed to have the composition above indicated. As for the minimum thickness to be given the lower part of the reservoir covered by water, that is expressed by the formula $W = 0{\cdot}01 + 0{\cdot}0104 H^2$, in which the thickness sought is expressed in meters.—*Les Annales des Travaux Publics.*

WORK DONE BY STEAM.

In order to correct the influence of the incorrect table of the horse power of steam engines of various sizes, published in several of the mechanical and milling papers, we consider below the question of steam of 100 pounds total pressure, which would correspond to about 85·5 pounds on the gauge in the Mississippi Valley, this being a pressure very frequently carried in mills where non-condensing engines are used. From the figures following any one having a non-condensing engine, and knowing the diameter of the piston and the length of the stroke, point of cut-off, and number of turns per minute, can calculate the horse-power which that engine would give out, assuming that full boiler pressure was maintained up to the point of cut-off; that there was no condensation, no friction nor back pressure, and that the clearance was seven per cent., which, however, is rather high.

One pound of steam at 100 pounds per square inch pressure above vacuum equals 85·5 pounds upon the ordinary steam gauge, which would be 14,400 pounds per square foot above vacuum, and takes up 4·33 cubic feet. If we multiply its absolute initial pressure by its volume we shall have (14,400×4·33=) 62,352 foot pounds. The constituent heat of one pound of steam at a pressure of 100 pounds absolute per square inch, as reckoned from 212° F., is 1001·4 units, and reckoned from 102° F. is 1111·4 units. Without any cut-off the work done by one pound of 100 pounds steam is 58,273 foot pounds, and it will take 34 pounds of dry steam per hour to furnish one horse power. With an actual expansion rate of 1·1 (which, with 7 per cent. clearance, would correspond to a cut-off of about 9-10, or, more exactly, 90·3 per cent. of the stroke), the work done per unit of steam is raised to 1·096 times that where full stroke is. With 4-5 cut-off, which, with 7 per cent. clearance, would give an actual expansion rate of 1·23, the work done would be 70,246 foot pounds, and the consumption of dry steam per hour per horse-power would be only 28·2 pounds. With cut-off at 75·3 per cent. of the stroke, and actual expansion rate of 1·3 the foot pounds would be 73,513, and the pounds of dry steam required to produce one horse power would be only 26·9. For 66·8 cut-off, which is nearly two-thirds, and actual expansion rate of 1·45, the foot pounds would be 79,555, and the quantity of dry steam per hour per horse-power would be only 24·9. With five-eighths cut-off and 1·54 actual expansion rate the ratio of work done would be increased to 1·425—that at full steam, the foot pounds 83,055, and the pounds of dry steam per hour per horse-power would be lessened to 23·8. With cut-off at half and actual expansion rate of 1·88, each pound of dry steam at 100 pounds per square inch absolute, would be doing 94,200 foot pounds of work, and only 21 pounds of it would be needed to produce one horse-power. At 37·6 per cent. cut-off, equal to 2·4 actual expansion rate, the foot pounds of work done by one pound of dry steam at 100 pounds absolute pressure are increased to 107,050, and only 18·5 pounds would be needed to produce one horse-power. With quarter cut off, 124,066 foot pounds, 19·7 per cent., or about one-fifth cut-off, 132,770 foot pounds; one-eighth cut-off, 146,357 foot pounds.

To make this table of use for other total initial pressures per square inch above vacuum, the following multipliers may be used in connection with the foot pounds of work done by the steam at 100 pounds absolute initial pressure; 65 pounds, 0·975; 70 pounds, 0·981; 75 pounds, 0·986; 80 pounds, 0·988; 85 pounds, 0·991; 90 pounds, 0·995; 95 pounds, 0·998. These multipliers are got by multiplying the total pressure of any other given steam per square foot by the volume in cubic feet of one pound of such steam, and dividing the product by 62,352, which is the product in foot pounds for steam of 100 pounds total pressure.—*American Miller.*

ROCHESTER CATHEDRAL.

The Roman high road from the Kentish seacoast to Londinium and Verulamium, and to the north-west, the road which is now called Watling-street, crossed the river Medway at Stroud; and there, on the opposite or right bank of the river, a fortress was built, which afterwards became the stronghold of Hrolf, a Saxon chieftain or king, and which got from him the name of Rolfchester, shortened into Rochester. When the papal missionary St. Augustine came to England, towards the beginning of the seventh Christian century, he established a bishopric of Rochester for the religious rule of West Kent. The first bishop was Justus, from the year 604 to 624; Paulinus, the apostle of Northumbria, was bishop of Rochester from 633 to 644. The excellent bishop of the diocese now is the Right Rev. Anthony W. Thorold, D.D., who signs himself "A. W. Roffen." He was, till five years ago, vicar of St. Pancras, Euston-square, and one of the best of London clergymen, which is saying a great deal. Between the seventh-century bishops and this present incumbency of Bishop Thorold, who has all South London and suburban Surrey to look after, together with West Kent, many famous prelates have occupied the see: Gundulf, who built the cathedral and the fine Norman castle, as well as parts of the Tower of London and of Dover Castle; Walter de Merton, who became Lord Chancellor under Henry III. and Edward I., and founder of Merton College, Oxford; Bishop Fisher, the chief adviser of "the Lady Margaret," Countess of Richmond and Derby, King Henry VII.'s mother, in her pious gifts and labors; he was the blameless victim, with good Sir Thomas More, of Henry VIII.'s bloodthirsty tyranny in 1535; Bishop Sprat, the time-serving trimmer of the Revolution period; and Bishop Atterbury, the Jacobite intriguer; besides many learned and devout men of no special renown.

The cathedral, of which Mr. S. Read has drawn a capital view, is composed of the Norman nave and crypt, and the choir and transepts of early English or primal Gothic style, with some decorated Gothic in the choir windows and in the chapter-house doorway. It is worth while to go to the top of Rochester Castle, and thence look down upon the whole edifice of the neighboring cathedral, which can hardly be seen to much advantage from any other external point of view, being inclosed with other buildings. The west front, except the great window, is of the Norman period, from 1077 to 1130; and consists of a center flanked by two turrets, and of two wings, the latter containing the entrances to the side aisles. The middle doorway presents five receding arches, moulded with rich sculptures, in the manner of some French cathedrals. The interior of the cathedral is generally plain, but the Norman arches, more especially the upper

ROCHESTER CATHEDRAL.—DRAWN BY S. READ.

tier of the nave, display some elaborate ornamentation. The north transept is also decorated. The tombs of Bishop Merton and others, here and in the chancel, are worthy of attention. In the south transept is the admired doorway of the chapter-house. A monument of Charles Dickens, who was born at Rochester and died at Gad's Hill, and whose last unfinished story, "Edwin Drood," contains more than one scene in the cathedral, will be regarded with much interest by the visitors to this fine old place.—*Illustrated London News.*

THE MANUFACTURING OF WOOL INTO CLOTH EXEMPLIFIED.*

I PROPOSE to talk to you this evening upon no new subject, but upon one that has been known for centuries, even in days of prehistoric times. Fragments of woven cloth have been found among the relics of the ancient Lake Dwellers. 1,200 years B.C., in the Heroic Age of ancient Greece, when it was no dishonor for the sons of the gods to cook their own dinner, women of high social rank carded, spun, and wove into cloth the wool gathered from the sheep of their husbands' flocks. Till within a comparatively few years, the distaff, the spindle, and the loom, all operated by hand and simple in construction, constituted the chief, if not sole outfit for converting the fleece of the sheep into cloth. The use of machinery, worked by mechanical power, is of modern invention, almost within the memory of men now living, some of the devices quite so. In my allusions to the various processes of manufacture, I mean those methods practiced by the modern woolen mill of New England. Most of the wool used in the mills of this country is of American growth; the duties imposed upon foreign wool are so great as to almost prohibit its importation. The best wool is that grown east of the Mississippi River, especially that of Western Virginia, Pennsylvania, and Ohio, and is generally washed on the sheep's back, or partially freed from extraneous matter, and in this condition sheared and sent to the market. West of the Mississippi the wool is not washed, but is sheared and marketed with all the grease and dirt belonging to the fleece.

The miniature bag of wool which I hold in my hand will show you the manner of packing all wool raised east of the Rocky Mountains. The envelope is called burlap, a material made from jute, a vegetable grown in the marshes of Bengal, and manufactured extensively in Dundee, Scotland, whence most of that used in this country is obtained. An ordinary sized bag is 2½ yards long, and one yard wide. You will notice that this bag has what is called an "ear" at each of the four corners. These ears are put on to facilitate the handling of the bag. I have put on this bag the number 200, to represent what may be considered the average weight of a bag of wool, those coming from west of the Mississippi, however, averaging more.

This is a miniature bale, and you cannot but observe that in form and general make-up it differs materially from what is designated as a bag of wool. Nearly all of the wool grown west of the Rocky Mountains comes to the New England manufacturer in this shape. The wool is first sent to San Francisco, where it is carefully classified according to its quality and condition, and then packed into bales which are subjected to heavy mechanical pressure, reducing the bulk to within a small compass of about 20 lb. to the square foot, and the whole bound with four or five iron hoops. This form of packing is done for the purpose of securing shipment at a less rate of freight, as a maximum of weight is obtained within a minimum of space. The average weight of a bale of wool is 500 pounds, and it occupies much less space than the same amount put into bags. At one end of the bale, called the head, you will notice certain marks, denoting the lot, the specific number of the bale, the quality of the wool, and the name of the grader or classifier.

In one of these two forms of packing the manufacturer gets his wool. The first process of manufacture, called sorting, now begins by spreading out each fleece on a partially inclined table, before a good light, to be separated into different qualities according to fineness. Every fleece has its own range of sorts. The finest sort is found on that part of the fleece which comes from the shoulder of the animal, and this is selected out and thrown into a bin by itself, and the same is done with the other qualities as found on the body, rump, thigh, and belly. Wool sorts may be known as picklock—which is the finest—first, second, and so on to seventh and eighth, which are very coarse. No one fleece has this full range of sorts, but it may have a range of four or five sorts. The practiced eye of the sorter can discriminate between two sorts, though the difference in the fineness of fiber may be only a ten-thousandth part of an inch. This lock of wool is, as it comes from the sheep, greasy and dirty. Before it can be used in manufacture it must be cleansed from these impurities, and the next process is for the purpose of effecting this object. I will take half of this sample and put it in this liquor and let it remain there for a few minutes. This operation is what is called scouring the wool, which is putting the wool into a liquor of strong detergent properties, yet it must not be so powerful in its corrosive action as to impair the strength of the wool. I have used here a liquor that is more generally relied upon than any other, the ingredients of which are caustic soda-ash and common salt. The salt is employed to correct some of the harsher characteristics of the soda-ash. The temperature of my liquor is about 115°, or not so hot but that the hand can be held in it without inconvenience. Too hot or too strong a liquor would injure the strength of the wool, stain it, and set, more or less, the animal grease. If the work is not done right here, the dyer is troubled in getting his color, aside from occasioning annoyances in other parts of the mill.

Important as this operation is, it is dependent oftentimes upon the most ignorant of factory help, because it is a wet and dirty job that few apply for. Having allowed the wool to remain in the liquor for a short time, it is taken out and drained, so that the liquor can return to the tub and be reused, for old liquor is better than new, and it is thrown away entirely only after becoming foul with dirt. The grease that is removed from the wool has of itself, in combination with the liquor ingredients, good cleansing properties, and in this respect gives value to the liquor as a detergent. The wool is next thrown into a rinsing box, where it is tossed about and washed in a strong current of water which enters the box at the bottom, and is given a whirling motion by the curved form of a copper bottom. The copper bottom is perforated with small holes, a sixteenth to an eighth of an inch in diameter, to allow the unclean water to pass off freely. As soon as the water runs clear the wool is taken out and is ready for coloring, which is the third process. I will take out the wool I have in the scouring liquor and wash it in this pail of clean water, to show you how white it will come out, and in a rude way illustrate the process I have described to you. You see the wool is white. It will look more flaky when dry. The wool is next submitted to the coloring process. The dye kettle is made of wood, either circular or rectangular, and large enough to hold about 200 pounds of clean wool. All heating is done by steam, introduced into the kettle by means of a wrought-iron pipe which runs along the bottom of the kettle and under a so-called false bottom, perforated with holes, put there to keep the wool from coming in contact with the steam pipe.

Every department in a woolen mill requires a great deal of skill and experience, far more than that needed in a cotton mill. A successful dyer must be familiar with the nature of his dyestuffs, the effect they will have upon the stock he has to color, as used alone or in combination with other materials. He should be familiar with chemistry as applied to dyeing, the effect of heat and light upon colors, the chemical properties of his coloring matters, and the changes and combinations to which they are liable. To illustrate the process of dyeing I shall undertake to show you a method of coloring wool green.

I have selected this color, as it is what is called a secondary color, or one made by the union of two elementary or primary colors, blue and yellow. I have here, over this lamp, a strong solution of alum, argol, extract of indigo, and fustic in a state of ebullition. Into this solution I will put some wool, cleansed from all extraneous matter, and let it boil a few minutes. In coloring a batch of wool in the dye-house, it would take an hour's boiling to do what I propose to accomplish in a few minutes; in other words, I have made my solution so strong that the fiber will be quickly impregnated with the coloring matter. I do this to hasten the exhibition, but it would be a wasteful operation in the dye-house. We will suppose a dyer is ordered to produce a certain shade of green, the very shade that I propose to get. In order to do this he must know the composition of the color green, which is the union of blue and yellow. Now he must select his proper dyestuffs which will impart blue and yellow, and of such characteristics as will freely combine with each other in conjunction with the mordants used.

The green he wants to get must be bright, therefore he selects for his blue constituent the extract of indigo, or, as it is sometimes called, sulphate of indigo, or, as the name implies, a solution of indigo in concentrated sulphuric acid. For his yellow he must find some dyestuff that will give the desired strength of color, and still work in common with the extract of indigo. He selects fustic, which he knows has good tinctorial power, and is but little affected by acids. *Fustic* is obtained from a large tree that grows in the West Indies and in Brazil. It is one of the most useful dyewares used in a mill. It gives the yellow in an orange, brown, and olive color, and is even used with logwood to produce black. If the art of the dyer was limited to the selection and use of his dye-drugs, his vocation would be one of comparative simplicity. Few dyes have the power of imparting their colors unaided to either silk, cotton, or wool, with any fixedness or permanency. They require a mediator that has a mutual affinity for the substance to be colored and the coloring matter, and this affinity must be held in such equilibrium that between the two it shall be equal. If the affinity is stronger for the dye than for the fiber, a precipitation takes place which drops to the bottom of the kettle, and leaves but a feeble deposit of color on the fiber. This mediator is called a mordant, from the French "mordre," to bite, as it was thought by the dyers of old that it bit into the fiber, and opened a way for the coloring matter to enter. A mordant must not only have an attraction for the fiber and the dye, but it must possess the antithetical characteristics of solubility and insolubility; solubility and liquidity when it is introduced to the fiber and dye, and insolubility after it has united with the dye. The one enables the dye to permeate the fiber, and the other to fix it there. The value of a mordant is measured largely by the intensity of its insolubility after its combination with the dye. Should I attempt to color my wool in a solution of extract and fustic alone, I should find that I had a color of little or no durability, one that could be easily washed out. To prevent this, I have used in my solution two mordants, *alum* and *argol*. Neither of these is a strong mordant when used alone, but together they are very effective. They are employed extensively in the dye-house for such colors as delicate shades of blue, pink, and yellow, or the tints of the three primary colors. Alum is one of the oldest mordants known. It is better to buy it in the lump, as being less liable to impurities. Argol is obtained from the juice of grapes and is not unfrequently found incrusted in a crystallized state on the inside of wine casks. Purified, we have what you all know as cream of tartar. It is a weak acid, and is not destructive to fustic.

I will now remove from the improvised kettle the wool that has been boiling in the coloring solution. You will observe that it comes out a bright green, just what was wanted. As you will notice, the coloring matter is not evenly distributed; some portions of the wool mass have a deeper shade of green than others. This is owing to some of the wool having freer access to the dyes, by being more open; or it may be on account of the imperfect cleansing of the wool. The first difficulty can be overcome only by constantly stirring the wool in the kettle by the use of long poles, thus breaking up any compact mass, and exposing every part of the wool batch equally to the dyes. When the coloring and mordanting are done in one dip, as I have done to-night, instead of two, the uniform distribution of the color cannot be so confidently depended upon. By two dips, I mean those processes technically called "preparing" and "finishing." The first, in which the wool is treated to the mordants alone; and the second, in which it is put into another kettle and subjected to the dyes that give the color. With the best of care absolute uniformity of color throughout the batch cannot be expected, nor is it essential. If the variation is not great, and there are no white spots, the irregularity will not be detected in the subsequent processes of picking and carding, which thoroughly mix the wool.

Before leaving the consideration of the dye-house, I wish to speak briefly upon what may be regarded as a collateral topic, though highly important for a true and scientific dyer to understand, viz.: *Color*. There are three elementary colors, termed "primary," from which all other colors are derived, and there are three composite colors, termed "secondary," formed by the combination of two of the primary colors. The three primary colors are red, yellow, and blue; and the three secondary colors are orange (the union of red and yellow), green (the union of yellow and blue), and violet (the union of blue and red). There is another color called indigo (the union of blue and violet), which, with the three primary and three secondary colors, make the seven colors of the solar spectrum, often designated as the "prismatic colors." To illustrate my observations I will construct a circular *chart* after the plan of Chevreul, a former director of the dye-works of the Gobelins at Paris.

If a pencil of white solar light be passed through a glass prism it will be refracted into the seven colors as just mentioned, and conversely the merging of the seven colors into one will produce a white pencil of light. If upon a disk the seven colors, or even the three primary colors, are painted, and the disk made to revolve with sufficient rapidity to blend the colors, the effect to the eye will be a white color. This may be termed the "optical composition" of these colors. On the other hand, if the three primary colors in pigments be mixed in certain proportions, black will be produced and this may be termed the "physical composition" of these colors. The optical composition and the physical composition of colors are two branches of the same study. The one belongs to the designer of the woven fabric, and the other to the art of the dyer. There are certain expressions applied to colors that it may not be amiss to speak of, namely, tone, shade, tint, and hue. The tone of a color is a term used to denote the modification which the color, in its greatest purity, experiences by the addition of black or white. By adding black to a pure color, you heighten the tone and produce what is called a shade. By adding white to a pure color, you lower the tone and produce a tint. The expression hue is employed to designate the modifications that a color undergoes by receiving a small quantity of another.

In the experiment we have had to-night in the production of a green, had I procured a pure green and desired to give it a bluish hue I should have added to the dyeing ingredients more extract of indigo, and had I desired a yellowish hue I should have added more fustic. Had I desired a tint of green I should have employed a less amount of the coloring materials, or had it been a shade I wanted I should have increased the quantity.

Scarlet is a hue of red inclining to yellow, and knowing that to be so the dyer forms his receipt by adding to his red dyes, perhaps some fustic, the same as used for my green, to give the yellow composition. Should he add enough fustic he would produce an orange.

Claret is another hue of red, but inclining to blue, and therefore to the red dyes some coloring material is added, such as logwood, to give the blue composition.

Pink is a tint of red, which the dyer gets by varying the proportions of the dyes that he uses in procuring a red. A first-class dyer should know the constitution of the color he wishes to produce, and the nature of the dyewares he has to employ, as well as the chemical effect of light and heat.

After the wool has been colored it is dried, either by spreading it on a platform out of doors, and exposing it to the rays of the sun, or by spreading it on wire netting indoors, and forcing through it heated or cold air by means of rapidly revolving fans.

It then goes to the picking room, when it is mechanically dusted and then spread out in thin layers, one above the other, each layer receiving a sprinkling of oil. The work done here is under the supervision of the overseers of the carding, and though the labor is often delegated to boys it is far from being unimportant. A batch of several hundred pounds of wool is mixed at a time. When ready, the boy or man as it may be, takes an armful vertically from the pile, that is, a portion from several layers, and puts it on the moving endless apron of a machine called a picker, which slowly delivers it to a cylindrical wheel, revolving 800 turns a minute, and armed on the periphery with numerous teeth shaped like the claws of the cat, that throws the wool in flakes like snow, into an adjoining room or bin. This operation of picking is repeated, so that the batch of wool becomes evenly and thoroughly mixed. It is now ready for carding. In the matter of oil that should be used on wool much could be said. Opinions vary as to the kind that is the best to meet the requirements of all the processes of manufacture. A wool oil must possess sufficient consistency to preserve from injury the delicate barbs of the fiber, and yet it must have enough fluidity to spread well so that every part shall have its proper and equal proportion. It must also be of such a nature as to scour out easily in the cloth. To meet these requirements to the best advantage an oil should be selected with the *oleine* greatly predominating over the *stearine*, two ingredients of all oils, and of such I do not know of any that excel either olive or lard oil, giving preference to the former, assuming the purity of both.

The operation of carding wool I cannot explain to you better than by the use of the diagram before you, which represents a machine called a first breaker, it being the first machine over which the wool is made to pass. The diagram is a longitudinal section of the machine, which you may consider as forty-eight inches wide, made up of a number of cylinders of different diameters, revolving at various velocities. The wool is brought in from the picking room, and put into bins by the side of this first breaker. A boy takes a small batch of it, carefully weighs a certain quantity on scales attached to the machine, made expressly for this purpose, and then spreads it evenly on what is termed the feed-table. This manipulation is now done in the best mills by means of a recently invented machine. From the feed-table, which is endless and moving toward the machine, the wool passes between two rolls, called the feed-rolls, and is delivered to the burr cylinder, which is made of steel, armed with numberless teeth, whence it is taken by the tumbler and carried to the main cylinder, which is four feet in diameter and is speeded at 110 revolutions to the minute, and from which it goes to the first worker, to be taken off by the stripper and again delivered to the main cylinder, to be carried to the second worker and stripper, and redelivered to the main cylinder for three more like operations. The process thus far constitutes the real carding as far as the first breaker machine is concerned. What follow are the means for getting the wool off the machine, and the first operation is that of the "fancy," the circumference of which revolves faster than that of the main cylinder, from which it brushes up the wool so that the doffer can receive it. From the doffer it is taken off by a vibrating steel comb and is drawn through a revolving tube on to a spool in one continuous sliver. This which I hold in my hand is a piece of a sliver, and as I open it you will observe that the fibers of wool are more or less parallel. Parallelism is the desideratum in carding; cleansing the wool of extraneous matter is incidental, though of value. The cylinders of the machine are covered by what is termed "card clothing," which is made of leather thickly set with fine wires, peculiarly bent, and, excepting the fancy, standing out a quarter of an inch from the leather. This which I exhibit to you is a piece of card clothing technically called the filleting, and used for all the cylinders with the exception of the main cylinder. The protruding wires are longer than these for the "fancy," but otherwise the same. The main cylinder is covered with clothing cut into "sheets," say 6 in. by 48 in., securely tacked on, otherwise not differing from the

* A lecture delivered at Reading, Mass., by HENRY G. KITTREDGE.

"filleting." The filleting is wound on the small cylinders and tacked at both ends. The wire teeth, as you will observe, are arranged in the leather in rows, and bent so as to serve the triple purpose of freely receiving, holding, and delivering the wool. Using these pieces of card clothing I will endeavor to illustrate the operations of the machine. The true carding of the wool is done by the main cylinder and workers, thus, straightening the fibers and giving them a degree of parallelism. The strippers remove the wool from the workers, thus, in a very clean manner, and readily part with it to the main cylinder. All subsequent processes are simply methods for getting the stock off the machine. After the first breaker, the stock has to pass over two other carding machines, the general operations of which are the same. From the second machine the wool comes off the same as from the first machine that is, in a sliver, only, as you will observe from the specimen before you, it is smoother, freer from lumps, and the fibers more uniform in parallelism. On the third machine, called the "finisher," the wool is carded the same as on the preceding two machines, but instead of coming off in one strand it comes off in a number of strands called "roving," which is wound on spools ready to be put on a spinning machine.

I have here some roving which is nearly perfect. It is necessary for good work that every strand should be of the same size and uniform, and when held between the eyes and the light no impurities should be visible.

The three carding machines that I have mentioned are together designated as a "set," which is always referred to when the productive capacity of a woolen mill is alluded to. A cotton mill has its capacity indicated by the number of spindles. The Washington Woolen Mills at Lawrence have 69 sets. The Atlantic Cotton Mills at Lawrence have 86,880 spindles. A set of wool carding machines will card on the average 100 lb. of clean wool a day. At this rate the Washington Mills would use 6,900 pounds of clean wool a day, or the production of 2,300 sheep; enough to clothe 1,210 men, or make a yarn of this size (5 runs) go round the earth at the equator one and one-sixth times.

The spools of roving are now taken to the spinning room, where the next process of manufacture is performed. The spools are put upon what is known either as a "jack," or as a mule, which is a machine for stretching and twisting the roving so as to give it fineness and strength, as well as greater uniformity of size. The jack is very long compared with its width, and carries usually 240 spindles, each of which whirls 4,000 times a minute. On the spindles are put the bobbins that receive the spun yarn. The spindles are fixed on to a "carriage" with wheels that run on stationary tracks, and it moves backward and forward; the backward motion is for the purpose of drawing out and reducing the size of the roving, while the forward motion is to take up and wind on the bobbins the yarn that has been spun. The spinning or twisting of the attenuated roving is done by a peculiar adjustment of the machine, which makes the yarn roll over the top of the bobbin in its seeming attempt to wind on the bobbin while the spindle is in a state of rapid revolution. Some of the motions of a mule or a self-operating jack are the prettiest of any machine in a mill. *With this strand* of roving I will try to illustrate the drawing out and reducing the roving to the size desired. While the roving is being drawn out it is undergoing more or less twisting, and the finest parts receive the twist the quickest, and in reverse ratio to the amount of twist so is the tendency to reduction, and as twisting imparts strength, so are the finest places, with the greater amount of twist, able to assist in drawing down the larger and more yielding places to greater uniformity of size. After the roving is reduced to the proper dimension, the spinning is completed by simply introducing more or less twist into the yarn, sufficient for the purposes for which it is required. *This bobbin* of yarn is for the woof of the cloth, more generally called the "filling," or that which runs across the cloth, and is spun with less twist than the warp, or that which runs lengthwise of the cloth. After the roving is spun into yarn and wound on the bobbin it is ready for the weave-room, in many respects the most interesting department in a woolen mill.

Archæological researches and discoveries have given indisputable evidences of the art of weaving existing in preadamic days. The art may have been practiced nearly concurrent with the being of man, as fragments of woven cloth have been found among the relics of the Lake Dwellers, who are supposed to have been about the first representatives of man. The Bronze Age furnishes specimens which place the art above most others in the degree of perfection, and though the remains of Switzerland and France give to us only linen fabrics, those of Denmark and Scandinavia, as well as of Yorkshire, England, contribute fabrics made from wool. The Bible furnishes the earliest record of the art of weaving. Job lamented that his days were passing with the fleetness of the weaver's shuttle; and Joseph was attired in "vestures of fine linen."

The ancient Peruvians and Egyptians have left to us proofs of their skill as weavers. At the Centennial Exposition of 1876, there was in the Peruvian department a piece of woven cloth taken from a tomb of the Incas, at least 2,000 years old, and in an excellent state of preservation, with the colors scarcely dimmed through a cycle of many centuries.

The principal advances in the art of weaving have been made during the last one hundred years.

Before a piece of cloth can be woven the warp has to be prepared for the loom, and to do that the yarn has to be taken from the bobbins and wound tightly on long spools, of the same size and construction as jack spools. These spools of yarn are then put into a "dressing machine," as many as are necessary to supply the required number of threads for the warp. On this machine the warp is properly arranged; the various colored yarns placed as it is wished to have them appear in the woven fabric, the starch dressing applied if need be to give strength, and the whole wound on a reel, and thence on to a long beam ready to be put into a loom. The warp threads are drawn through heddles like this one, which are fine twisted wires with eyelets in the center, and through each eyelet is passed one thread. The heddles are affixed to frames called harnesses, and it is the varied movements of the harnesses that give to the cloth the style of weaving. The weft, or as generally called inside the mill, the filling, is introduced between the warp by means of a shuttle which is thrown from one side of the loom to the other, from eighty to a hundred times a minute. I have here a *shuttle* made from apple-tree wood, an excellent material for the purpose; and on the spindle I put a bobbin of yarn, which is held securely in its place by a spring and catch. The yarn is now drawn through a hole or eye at the side of the shuttle, by a small hook, or by suction, which is an unhealthy practice some weavers have, of placing the mouth at the eye and sucking the yarn through, thus getting more or less of lint into the lungs. The shuttle is now ready for use, and as it is made to traverse the warp it leaves some of the yarn as it unwinds from the bobbin. The shuttle has nothing to do with the style of weaving, that, as I have said, belongs to the harnesses; but it has often an important part to perform in the distribution of several colors, in which case more than one shuttle is used; there are as many used as there are colors.

The mechanism of a loom for weaving fancy cassimeres, etc., I shall not be able to explain to you in an intelligible manner, unless you have seen such a loom, and are more or less familiar with its working. I will, however, dwell briefly upon the art of designing the style and pattern of woolen fabrics. To be a successful designer, a person should be well acquainted with the operations of a loom, and the effect produced by those operations; and he should be well versed in the laws of contrast of colors, and above all possess a natural taste and aptitude for the vocation. American mills are becoming more and more original every year in their designs, imitating foreign makes only in ideas. It was comparatively but a few years since the profession of an American designer, with occasional exceptions, was misnamed; and, instead of inventing, was simply copying by dissecting a piece of cloth and reproducing it. The principles of designing are simple and few; but it is their application in combination that makes the art difficult and perplexing. The design must be made agreeably to the effect that is intended to be produced. The designer delineates his pattern upon paper, which is marked off into square sections that are subdivided into sixty four little squares, like this which I will draw on the blackboard. The sections of sixty-four little squares are for convenience' sake for ready computation. The little squares taken longitudinally represent the warp, and when taken transversely represent the weft or filling. The pieces of cloth which I now pass among you are from what is known as ladies' cloth. You will observe the weaving to be like that of cotton sheeting—that is, a plain weaving, the simplest that can be devised. This weaving taxes the strength of the warp more than any other, and receives the weft with greater reluctancy. It is also more difficult to felt. On the other hand, it is the most durable of any that can be given to a fabric. To represent this weaving on the designing tablet, I will mark off diagonally two of the little squares, with crosses. The pattern, as you see, requires but two threads of warp; and it is the alternate up-and-down motion of these that constitutes the plain weave. The pattern is many times repeated in the cloth, one-half as many times as there are threads in the warp and weft. In this the back and face of the cloth are alike, the amount of warp and weft being in equal proportion on either side. Generally speaking it requires as many harnesses in a loom as there are warp threads in the pattern; and as there are two warp threads in a plain pattern a loom must carry two harnesses.

I will now pass among you pieces of cloth having a different weave. You will observe that the cloth is ribbed, and that on one rib there is a fine twill running in one direction, and on the next rib a fine twill running in a contrary direction, while on the back the yarn is coarse, loosely woven, and rough. It is a worsted fancy cassimere with a backing. There are several things to consider in this cloth. In the first place, let us take the twill on one of the ribs, and we find it to be a four-harness twill, requiring four threads in the warp and four threads in the weft to make the pattern. I will represent this weave on the tablet. As I have remarked, the squares taken longitudinally stand for the warp threads, and taken transversely, stand for the filling or weft threads. I will commence at the left hand and number the warp threads one, two, three, and four; and commencing at the top I will number the filling threads one, two, three, and four. That is all that is needed for the pattern. If you please we will remember this plan of enumeration in the subsequent explanations. I will mark off warp threads one and two, then two and three, then three and four, then four and one. This is meant to show that filling-thread one passes under warp-threads one and two, and over three and four; and filling two over warp one, under warp two and three, and over warp four, and so on for the remaining filling threads, three and four. This four-harness pattern is repeated four times for the rib, requiring in all sixteen harnesses, or warp threads, which I will indicate in the design. For the next rib you will notice the twill runs in a contrary direction, having the same weave, only in a divergent order, and this I will represent in the design. We have now for the two ribs thirty-two warp threads, which are needed to complete the full pattern. This design is repeated one half as many times as there are ribs in the cloth. I will simply say that by a simple process of reduction this design can be woven with four harnesses. If this was all, you would have a smooth piece of cloth of a herring-bone style without ribs. What gives the rib elevation is the introduction into the weave of the backing thread. This thread is in the weft, and serves the double purpose of producing a rib and adding weight to the fabric; and as it does not show on the face of the goods it can be made from inferior grade of stock. The position the backing thread occupies in the pattern I will express in the design, showing that it has no connection with the face weave, except in the simple overlapping of one warp thread out of every sixteen. In the subsequent process of fulling, which narrows the cloth, the backing, being free and untrammeled, more readily contracts, and in so doing throws the face upward and produces the rib. While the plain weave is very trying on the warp, the twill weave of all kinds is very easy.

I wish to pass among you samples of a basket style of weaving, which can be used with very pretty effect. I will show the design on the tablet.

The pattern calls for four threads in the warp and four in the filling. Warp threads one and two are raised, and three and four depressed to receive filling threads one and two, and warp threads three and four are raised and one and two depressed to receive filling threads three and four. What I have shown you are the very simplest of weaves, but alone, or in combination, they can be used with very pretty effect in colors.

I spoke to you on the subject of colors, in connection with dyeing. I will again refer to it in connection with the art of designing. The designer wants to know the effect of color as it appeals to the eye. The colors that should be introduced into a fabric must depend upon the use to which it is to be put, or the taste of the consumer. What would please the people of the South might not please the people of the North. The taste of the Italian would not be that of the Norwegian, nor the taste of the Mexican that of the American. A fabric for ladies' wear would probably call for different colors than one for gentlemen's wear. Again directing your attention to the color chart used in my former explanation, red and green, yellow and violet, blue and orange, stand to one another as complementary colors, each aiding the other in intensifying its tone. Strongly contrasting colors can often be used with pleasing effect in stripes, checks, and broken figures, when not made too prominent. By putting together two colors of different depth of tone, that which is deep will appear deeper, and that which is light will appear lighter. This you will observe in the black and white basket sample which I gave you. The black is made to appear a brighter black and the white a clearer white. Were the colors a dark red and a light green, the red would appear a deeper red and the green a lighter green. The dark color seems to lose its white light, and impart it to the lighter color. The physical composition of dyes, and the optical composition of contiguous colors producing simultaneous contrast of colors, may be termed as the positive and negative composition of colors, or the attractive and repulsive composition of colors. These two features are respectively the study of the dyer and the designer. To illustrate. The union of red and yellow dyes will produce an orange. This I call the positive or attractive composition of colors. Place the colors red and yellow in juxtaposition and the red will incline to violet and the yellow to green. This I call the negative or repulsive composition of colors. The same may be said of orange and green if placed in contiguity. The orange will lose some of its yellow and appear redder, and the green will also lose some of its yellow and appear bluer; and both colors are intensified. The whole scale of colors can be gone through with in the same way.

The next and last process of manufacture is what is technically known as finishing, which is the manipulation of the woven fabric through certain operations preparatory to its becoming an article of clothing. The cloth as it comes from the loom is called the "flannel," and it is greasy and dirty, and to remove these impurities is the first thing to be attended to. This is done in a machine called a washer, shaped much like a box, very deep, with a circular bottom, and carrying near the top two very heavy wooden rollers, between which the cloth is made to revolve, the two ends of the cloth being tacked, or sewed together. I have represented before you a vertical section of a washer, showing the rollers, etc. While the cloth is in motion a warm solution of soap is slowly poured upon it till there is a sufficient quantity in the machine to thoroughly wet the cloth. The cloth is allowed to run in the solution till the dirt and grease are loosened and dissolved, when streams of clear cold water are turned on through large pipes to wash the cloth clean of every impurity. About a ninth part of the weight of the flannel as it comes from the loom is dirt and grease. The cloth is next fulled, which is done by passing it rapidly between two heavy revolving rollers, for several hours, it being kept at all times thoroughly wet by a specially prepared warm solution of soap. By fulling, the cloth is shrunk in width from thirty-six inches to twenty-seven inches. These figures I give to convey an idea of the shrinkage; they are approximate. The standard measurement for single width goods, or cassimeres, is twenty-seven inches, finished ready for the market. Processes subsequent to fulling have a tendency to shrink the cloth in width, so that in fulling it is not always best to narrow the cloth to twenty-seven inches, but rather allow it to be a little wider than that. The art of fulling has been known from time immemorial. Working the cloth in a tub with the feet was an ancient method that was practiced to some extent in Europe into the tenth and eleventh centuries. The purpose of fulling is to felt, or entangle the fibers of wool together so as to give the fabric a compactness, and in doing so the width and length are contracted. To accomplish this a certain degree of heat is needed with a soap having some alkali. The art of fulling cannot be governed by fixed rules, and the same may be said of everything connected with the finishing department; experience, judgment, and care are the necessary qualifications of the operator. Should the soap solution be too hot, or too strong of alkali, or applied to the cloth unevenly, or should the temperature in the machine be too high, damage of some kind would be the result. It is here that colors are ruined, cloths made tender, and numerous other evils occur. There are some cloths of the cheaper class that are weighted with flocks being stuffed into them. Flocks prepared for this purpose are bits of woolen rags or refuse fibers of wool, cut or ground to the fineness of powder. I have here a sample of this kind of *flocks*. They are forced into the cloth in the fulling mill during the process of felting, the large rollers doing the pounding in, and are applied to the back of the fabric. So skillfully is this done, that detection is difficult. They give the fabric a firmer feeling, and by filling the interstices oftentimes improve the appearance. As might be supposed, their tenancy is unreliable and they are easily worn out of the cloth, as many of you may have noticed in some of your garments. I have here specimens of cloths in the flannel state as they come from the loom, and the same after they are fulled and finished. One is that of a cassimere, and the other of a cotton warp union beaver. In the first condition they are sleazy, and in the second firm and compact. The union beaver will interest you more by my telling you that the warp is cotton, and the weft, or filling, eighty-five per cent. shoddy and fifteen per cent. wool, and well filled with flocks. It is colored in the piece, after fulling. Considering its composition it is a handsome piece of goods, and unless you were an adept you would probably be deceived in its purchase.

After fulling, the fabric is again washed to cleanse it of soap, etc., and it is then subjected to a process for raising a nap, called gigging. This is done on a machine having a large wheel, wider than the cloth, on the periphery of which are fastened iron frames filled with a numerous supply of teasels, which, while in rapid motion, are brought in contact with the face of the cloth till a sufficient nap is raised. The nap covers up and alleviates the harsh and angular appearance of the cloth. Gigging, if for no other purpose, raises the loose fibers on the surface of the cloth so they can be cut off in the subsequent process of shearing, and gives to it a clearer and cleaner aspect. I have a few teasels which I will have passed for your examination, as they exercise an important function in the manufacture of woolen goods, and no ingenuity of man has ever invented a substitute for them. This little homely product of nature has defied the genius of man for more than eighteen centuries. No steel has ever been so delicately tempered as to equal it for the critical work required of it. It is a native of Europe, and known as the fuller's teasel, though cultivated to a large extent in this country, from which nearly all, if not all, of our mills' supply comes. The rigid scales, with curved sharp apexes, furnish to the teasel its chief value for raising the nap on woolen fabrics.

The amount and manner of gigging depend entirely upon the kind of goods treated, and the style of finish desired. Worsted suitings require little or no gigging; ordinary cassimeres enough to give a clear and smooth face; while broadcloths and beavers demand a large amount of handling and re-handling, consuming a great deal of time. For the lat-

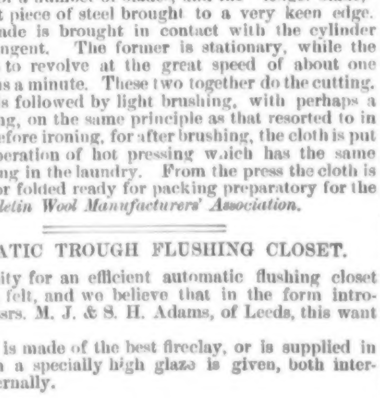
ter, gigging is alternated a number of times with shearing, for the purpose of giving a thick or dense nap. Shearing at this stage of manufacture is called "cropping," a process of clipping off the nap to allow the teasels to get more into the goods so as to produce a thick bottom to the nap. The lustrous appearance of what are termed "faced goods," such as doeskins, broadcloths, etc., though not a little attributable to gigging, is due more particularly to boiling the fabrics in water for many hours. The accomplishment of this process is to tightly roll the fabrics on wooden rolls and place them in a large wooden kettle filled with water which is brought to a boiling point, and so sustained for a period of hours. After gigging, the cloth is dried, either on a machine where the heat is derived from steam, or on "tenter-bars" located out of doors and exposed to the rays of the sun.

Tenter-bars are of a framework construction so contrived as to stretch the cloth to the proper width by means of tenter-hooks, right-angled hooks, *like this one*, and there held till it is fully dried. Next, the cloth is brushed by means of one or two rotary brushes, or it passes at once to the "finishing" shear, a machine which cuts the nap to its proper length. The shearing machine requires the most careful handling of any machine in the finishing department. All its adjustments should be very exact. The best discerning judgment of the department has to be employed on it. The principal parts of the machine are the "cylinder," which consists of a helicoidal arrangement of a number of blades, and the "ledger-blade," which is a flat piece of steel brought to a very keen edge. The ledger-blade is brought in contact with the cylinder almost at a tangent. The former is stationary, while the latter is made to revolve at the great speed of about one thousand turns a minute. These two together do the cutting. This process is followed by light brushing, with perhaps a gentle steaming, on the same principle as that resorted to in the laundry before ironing, for after brushing, the cloth is put through an operation of hot pressing which has the same effect as ironing in the laundry. From the press the cloth is either rolled or folded ready for packing preparatory for the market.—*Bulletin Wool Manufacturers' Association.*

AUTOMATIC TROUGH FLUSHING CLOSET.

THE necessity for an efficient automatic flushing closet has long been felt, and we believe that in the form introduced by Messrs. M. J. & S. H. Adams, of Leeds, this want is met.

The trough is made of the best fireclay, or is supplied in iron, to which a specially high glaze is given, both internally and externally.



It is readily fixed by any workman. It is so constructed that the full length is utilized for seats, none being wasted by the valve-chamber as in the ordinary trough flushing closet.

When waste water from yard sinks, slop water, etc., is led into the trough, only a very limited amount (if any) of other water is required for use in the after-flushing; where no such connections are made, the closet works with the amount of water usually allowed for such purposes by water companies (this being regulated by a plain ball-tap, unless otherwise ordered). The trough, when ready, discharges its contents by means of the patent siphon, which is fully charged on the instant. The siphon is equal to a four inch pipe, and will therefore carry off all matter without the fear of choking. The closet will work without attention for an unlimited time. It may be built to any length. The cross section given herewith shows the construction.—*Building News.*

THE TIDES AND THE LENGTHENING DAY.*

By Professor ROBERT S. BALL, LL.D., F.R.S.

THE cause of the ebb and flow of the tides has long ceased to be a mystery. In the earliest times it was noticed that the tides were connected with the moon. Pliny and Aristotle both refer to the alliance between the tides and the age of the moon. For many centuries, perhaps, indeed, for thousands of years, observant men might have known that the moon and the tides were connected. But they did not know any reason why this connection should exist. I dare say they did not even know whether the moon was the cause of the tides or the tides the cause of the moon.

Nor is it easy to explain the tides. We were all taught that the moon makes the tides. Yet I can imagine an objector to say: "If the moon makes the tides, why does it give Bristol a splendid tide of forty feet, while London is put off with only eighteen?" The true answer is that the height of the tide is largely affected by local circumstances, by the outline of the coasts, by estuaries and channels. It is even affected to some extent by the wind. Into such details, however, I do not now enter; all I require is that you shall admit that the moon causes the tides, and that the tides cause currents.

Though we have not yet put the tides into harness, yet tides are not idle. Work they will do, whether useful or not. In some places the tidal currents are scouring out the river channels; in others they are moving sand banks. From a scientific point of view the work done by the tides is of unspeakable importance. To realize the importance, let us ask the question, Whence is this energy derived with which the tides do their work? The tidal wave produced by the moon is the means whereby a part of the energy stored in the earth is compelled to expend itself in work. I do not say this is an obvious result. Indeed it depends upon a refined dynamical theorem, which it would be impossible to enter into here.

* Abstract of a lecture delivered at the Midland Institute, Birmingham, England.

But what do we mean by taking energy from the earth? Let me illustrate this by a comparison between the earth rotating on its axis and the fly-wheel of an engine. The fly-wheel is a sort of reservoir, into which the engine pours its power at each stroke of the piston. The various machines in the mill merely draw off the power from the store accumulated in the fly-wheel. The earth is like a gigantic fly-wheel detached from the engine, though still connected with the machines in the mill. In that mighty fly-wheel a stupendous quantity of energy is stored up, and a stupendous quantity of energy would be given out before that fly-wheel would come to rest. The earth's rotation is the reservoir from whence the tides draw the energy they require for doing work. Hence it is that though the tides are caused by the moon, yet whenever they require energy they draw on the supply ready to hand in the rotation of the earth.

The earth differs from the fly-wheel of the engine in a very important point. As the energy is withdrawn from the fly-wheel by the machines in the mill, so it is restored thereto by the power of the steam engine, and the fly runs uniformly. But the earth is merely the fly-wheel without the engine. When the work done by the tides withdraws energy from the earth, that energy is never restored. It therefore follows that the energy of the earth's rotation must be decreasing. This leads to a consequence of the most wonderful importance. It tells us that the speed with which the earth rotates on its axis is diminishing. We can state the result in a manner which has the merits of simplicity and brevity.

"The tides are increasing the length of the day."

This statement is the text of the discourse which I am to give you this evening. From this simple fact the new and wondrous theory of tidal evolution is deduced.

At present no doubt the effect of the tides in changing the length of the day is very small. A day now is not appreciably longer than a day a hundred years ago. Even in a thousand years the change in the length of the day is only a fraction of a second. But the importance arises from the fact that the change, slow though it is, lies always in one direction. The day is continually increasing. In millions of years the accumulated effect becomes not only appreciable but even of startling magnitude.

The change in the length of the day must involve a corresponding change in the motion of the moon. This is by no means obvious. It depends upon an elaborate mathematical theorem. I cannot attempt to prove this for you, but I think I can state the result so that it can be understood without the proof. If the moon acts on the earth and retards the rotation of the earth, so, conversely, does the earth react upon the moon. The earth is tormented by the moon, so it strives to drive away its persecutor. At present the moon revolves round the earth at a distance of about 240,000 miles. The reaction of the earth tends to increase that distance, and to force the moon to revolve in an orbit which is continually getting larger and larger.

Here then we have two remarkable consequences of the tides which are inseparably connected. Remember also that we are not enunciating any mere speculative doctrine. These results are the inevitable consequences of the tides. If the earth had no seas or oceans, no lakes or rivers; if it were an absolutely rigid solid throughout its entire mass, then these changes could not take place. The length of the day would never alter, and the distance of the moon would only fluctuate between narrow limits.

As thousands of years roll on, the length of the day increases second by second, and the distance of the moon increases mile by mile. These changes are never reversed. It is the old story of the perpetual dropping. As the perpetual dropping wears away the stone, so the perpetual action of the tides has sculptured out the earth and moon. Still the action of the tides continues. To-day is longer than yesterday; yesterday is longer than the day before. A million years ago the day probably contained some minutes less than our present day of twenty-four hours. Our retrospect does not halt here; we at once project our view back to an incredibly remote epoch which was a crisis in the history of our system.

Let me say at once that there is great uncertainty about the date of that crisis. It must have been at least 50,000,000 years ago. It may have been very much earlier. This crisis was the interesting occasion when the moon was born. I wish I could chronicle the event with perfect accuracy, but I cannot be sure of anything except that it was more than 50,000,000 years ago.

At the critical epoch to which our retrospect extends, the length of the day was only a very few hours. I cannot tell you exactly how many hours. It seems, however, to have been more than two and less than four. If we call it three hours we shall not be far from the truth. Perhaps you may think that if we looked back to a still earlier epoch, the day would become still less and finally disappear altogether! This is, however, not the case. The day can never have been much less than three hours in the present order of things. Everybody knows that the earth is not a sphere, but that there is a protuberance at the equator, so that, as our school books tell us, the earth is shaped like an orange. It is well known that this protuberance is due to the rotation of the earth on its axis, by which the equatorial parts bulge out by centrifugal force. The quicker the earth rotates the greater is the protuberance. If, however, the rate of rotation exceeds a certain limit the equatorial portions of the earth could no longer cling together. The attraction which unites them would be overcome by centrifugal force and a general break up would occur. It can be shown that the rotation of the earth when on the point of rupture corresponds to a length of the day somewhere about the critical value of three hours, which we have already adopted. It is therefore impossible for us to suppose a day much shorter than three hours. What occurred prior to this I do not here discuss.

Let us leave the earth for a few minutes, and examine the past history of the moon. We have seen the moon revolves around the earth in an ever-widening orbit, and consequently the moon must in ancient times have been nearer the earth than it is now. No doubt the change is slow. There is not much difference between the orbit of the moon a thousand years ago and the orbit in which the moon is now moving.

But when we rise to millions of years the difference becomes very appreciable. Thirty or forty millions of years ago the moon was much closer to the earth than it is at present; very possibly the moon was then only half its present distance. We must, however, look still earlier, to a certain epoch not less than fifty millions of years ago. At that epoch the moon must have been so close to the earth that the two bodies were almost touching.

Everybody knows that the moon revolves now around the earth in a period of twenty-seven days. The period depends upon the distance between the earth and the moon. The time and the distance are connected together by one of Kepler's celebrated laws, so that, as the distance shortens, so must the time of revolution shorten. In earlier times the month must have been shorter than our present month. Some millions of years ago the moon completed its journey in a week instead of taking twenty-eight days, as at present. Looking back earlier still, we find the month has dwindled down to a day, then down to a few hours, until at that wondrous epoch when the moon was almost touching the earth, the moon spun round the earth once every three hours.

We have hitherto been guided by the unerring light of dynamics, but at this momentous epoch dynamics deserts us, and we have only probability to guide our faltering steps. One hint, however, dynamics does give. It reminds us that a rotation once in three hours is very close to the quickest rotation which the earth could have without falling to pieces. As the earth was thus predisposed to rupture, it is of extreme interest to observe that a cause tending to precipitate such a rupture was then ready to hand. It seems not unlikely that we are indebted to the sun as the occasion by which the moon was fractured off from the earth and assumed the dignity of an independent body. It must be remembered that the sun produces tides in the earth as well as the moon, but the solar tides are so small compared with the lunar tides, that we have hitherto been enabled to neglect them. There could, however, have been no lunar tides before the moon existed, and consequently in the early ages before the moon was detached, the earth was disturbed by the solar tides, and by the solar tides alone.

The primeval earth thus rose and fell under the tidal action of the sun. Probably there were no oceans then on the earth; but tides do not require oceans or even water for their operation. The primitive tides were manifested as throbs in the actual body of the earth itself, which was then in a more or less fluid condition. Even at this moment, bodily tides are disturbing the solid earth beneath our feet; but these tides are now so small as to be imperceptible when compared with the oceanic tides.

At the remote epoch of which we are speaking the solar tides were very small, as they are at present. Yet, small as they are, there was a particular circumstance which may have enormously increased their importance. The point to which I refer can be illustrated very simply. We have here a weight of fourteen pounds freely suspended, and here I have a small wooden mallet which barely weighs half an ounce, yet, small as this mallet is, I can make the heavy weight swing by merely giving it blows with the mallet. Let me try. I give the weight blow after blow. I hit it as hard as I can, yet the weight hardly swings. I have not yet been successful. The art of succeeding is merely to time the blows properly; this I am now doing, and you see the weight swings in an arc which is steadily augmenting.

We therefore see that a succession of impulses, in themselves small, can yet produce a great effect when they are properly timed. In the present case the impulses should succeed each other at the same interval as this pendulum requires for one to-and-fro oscillation. The time therefore depends on the body struck, and not at all on the body which gives the impulses.

Just as this pendulum swings with a definite period, so the vibrations of the primeval earth had a certain period appropriate to them. Suppose that the liquid primeval globe were pressed in on two quadrants and drawn out on the two others, and that the pressures were then released. The globe would attempt to regain its original form, but this it could not do at once, any more than the pendulum can at once regain its vertical position; the protruded portions would go in, but they would overshoot the mark, and the globe would thus oscillate to and fro. Now it has been shown that the period of such oscillations in our primitive globe is about an hour and a half, or very close to half the supposed length of the day at that time. The solar tides, however, also have a period half the length of the day. Here then we have a case precisely analogous to the fourteen-pound weight I have just experimented on. We have a succession of small impulses given which are timed to harmonize with the natural vibrations. Just as the small timed impulses raised a large vibration in the weight, so the small solar tides on the earth threw the earth into a large vibration. At first these vibrations were small, but at each succeeding impulse the amplitude was augmented, until at length the cohesion of the molten matter could no longer resist; a separation took place; one portion consolidated to form our present earth; the other portion consolidated to form the moon.

There is no doubt whatever that the moon was once quite close to the earth; but we have to speculate as to what brought the moon into that position. I have given you what I believe to be the most reasonable explanation, and I commend it to your attention. There are difficulties about it, no doubt; let me glance at one of them.

I can easily imagine an objector to say: "If the moon were merely a fragment torn off, how can we conceive that it should have that beautiful globular form which we now see? Ought not the moon to have rugged corners and an irregular shape? and ought not the earth to show a frightful scar at the spot where so large a portion of its mass was rent off?"

You must remember that in those early times the earth was not the rigid solid mass on which we now stand. The earth was then so hot as to be partially soft, if not actually molten. If then a fragment were detached from the earth, that fragment would be a soft yielding mass. Not for long would that fragment retain an irregular form; the mutual attraction of the particles would draw the mass together. By the same gentle ministrations the wound on the earth would soon be healed. In the lapse of time the earth would become as whole as ever, and at last it would not retain even a scar to testify to the mighty catastrophe.

I am quite sure that in so large and so cultivated an audience as that which I am now addressing, there are many persons who take a deep interest in the great science of geology. I believe, however, that the geologist who had studied all the text books in existence might still be unacquainted with the very modern researches which I am attempting to set forth. Yet it seems to me that the geologists must quickly take heed of these researches. They have the most startling and important bearing on the prevailing creeds in geology. One of the principal creeds they absolutely demolish.

I suppose the most read book that has ever been written on geology is Sir Charles Lyell's "Principles." The feature which characterizes Lyell's work is expressed in the title of the book, "Modern Changes of the Earth and its Inhabitants Considered as Illustrative of Geology." Lyell shows how the changes now going on in the earth have in course of time produced great effects. He points out triumphantly that there is no need of supposing mighty deluges and frightful earthquakes to account for the main facts of geology.

Lyell attempts to show that the present action of winds

and storms, of rains and rivers, of ice and snow, of waves and tides, will account for the formation of strata, and that the gentle oscillations of the earth's crust will explain the varying distribution of land and water. In this we can to a great extent follow him. I am quite satisfied with the oscillations in the land. If the land rises an inch or two every century in one place and falls to the same extent elsewhere, all that is required has been explained. Nor do I feel at present disposed to question his views as to rivers or to glaciers, to rains or to winds. There is, however, one great natural agent of which Lyell does not take adequate account. He does not attach enough importance to the tides. No doubt he admits that the tides do some geological work. He even thinks they can do a great deal of work. The sea batters the cliffs on the coasts, and wears them into sand and pebbles. The glaciers grind down the mountains, the rains and frosts wear the land into mud, and rivers carry that mud into the sea. In the calm depths of ocean this mud subsides to the bottom; it becomes consolidated into rocks; in the course of time these rocks again become raised to form the dry land with which we are acquainted.

The tides, says Lyell, help in this work. Tidal currents aid in carrying the mud out to sea; they aid to a considerable extent in the actual work of degradation, and thus contribute their quota to the manufacture of stratified rocks. Such is the modest *rôle* which Lyell has assigned to the tides, and no doubt the majority of geologists have acquiesced in this doctrine. Nor can there be any doubt that this is a just view of tidal action at present. That it is a just view of tidal action in past times is what I now deny. Lyell did not know—Lyell could not have known—that our tides are but the feeble surviving ripples of mighty tides with which our oceans once pulsated. Introduce these mighty tides among our geological agents, and see how waves and storms, rivers and glaciers, will hide their diminished heads.

I must attempt to illustrate this view of tidal importance in ancient geological times. Let me try by the aid of the tides to explain the great difficulty which every one must have felt in regard to Lyell's theory. I allude to the stupendous thickness of the Paleozoic rocks.

Look back through the corridors of time in the manner in which they are presented to us in the successive epochs of geology. We pass rapidly over the brief career of prehistoric man; then through the long ages of tertiary rocks, when the great mammals were developed; back again to the much earlier period when colossal reptiles and birds were the chief inhabitants of the earth; back again to those still earlier ages when the luxuriant forests flourished that have given birth to the coal fields; back once more to the age of fishes; back finally to those earliest periods when the lowest forms of life began to dawn in the paleozoic era.

As we date remote ages astronomically by the distance of the moon, so we date remote ages geologically by the prevailing organic life. It is a great desideratum to harmonize these two chronological systems, and to find out, if possible, what lunar distance corresponds to each geological epoch. In the whole field of natural science there is no more noble problem. Take, for example, that earliest and most interesting epoch when life perhaps commenced on the earth, and when stratified rocks were deposited five or ten miles thick, which seem to have contained no living forms higher than the humble eozoon, if even that were an organized being. Let us ask what the distance of the moon was at the time when those stupendous beds of sediment were deposited in the primeval ocean. We have in this comparison every element of uncertainty except one. The exception is, however, all important. We know that the moon must have been nearer to the earth than it is at present. There are many very weighty reasons for supposing that the moon must have been very much nearer than it is now. It is not at all unlikely that the moon may then have been situated at only a small fraction of its present distance. My argument is only modified, but not destroyed, whatever fraction we may take. We must take some estimate for the purpose of illustration. I have had considerable doubts what estimate to adopt. I am desirous of making my argument strong enough, but I do not want to make it seem exaggerated. At present the moon is two hundred and forty thousand miles away; but there was a time when the moon was only one-sixth part of this, or say forty thousand miles away. That time must have corresponded to some geological epoch. It may have been earlier than the time when the eozoon lived. It is more likely to have been later. I want to point out that when the moon was only forty thousand miles away, we had in it a geological engine of transcendent power.

On the primitive oceans the moon raised tides as it does at present; but the forty-thousand-mile moon was a far more efficient tide producer than our two-hundred-and-forty-thousand-mile moon. The nearer the moon the greater the tide. To express the relation accurately, we say that the efficiency of the moon in producing tides varies inversely as the cube of its distance. Here then we have the means of calculating the tidal efficiency for any moon distance. The forty-thousand-mile moon being at a distance of only one-sixth of our present moon's distance, its tidal efficiency would be increased 6×6×6 fold. In other words, when our moon was only forty thousand miles away, it was two hundred and sixteen times as good a tide producer as it is at present.

The height to which the tides rise and fall is so profoundly modified by the coasts and by the depth of the sea, that at present we find at different localities tides of only a few inches and tides of sixty or seventy feet. In ancient times there were no doubt also great varieties in the tidal heights owing to local circumstances. To continue our calculation, we must take some present tide. Let us discard the extremes just indicated and take a moderate tide of three feet rise and three feet fall as a type of our present tides. On this supposition what is to be a typical example of a tide raised by the forty-thousand-mile moon? If the present tides be three feet, and if the early tides be two hundred and sixteen times their present amount, then it is plain that the ancient tides must have been six hundred and forty-eight feet.

There can be no doubt that in ancient times tides of this amount and even tides very much larger must have occurred. I ask the geologists to take account of these facts, and to consider the effect—a tidal rise and fall of 648 feet twice every day.

These mighty tides are the gift which astronomers have now made to the working machinery of the geologist. They constitute an engine of terrific power to aid in the great work of geology. What would the puny efforts of water in other ways accomplish when compared with these majestic tides and the great currents they produce?

In the great primeval tides will probably be found the explanation of what has long been a reproach to geology. The early paleozoic rocks form a stupendous mass of ocean-made beds which, according to Professor Williamson, are twenty miles thick up to the top of the silurian beds. It has long been a difficulty to conceive how such a gigantic quantity of material could have been ground up and deposited at the bottom of the sea. The geologists said: "The rivers and other agents of the present day will do it if you give them time enough." But unfortunately the mathematicians and the natural philosophers would not give them time enough, and they ordered the geologists to "hurry up their phenomena." The mathematicians had other reasons for believing that the earth could not have been so old as the geologists demanded. Now, however, the mathematicians have discovered the new and stupendous tidal grinding-engine. With this powerful aid the geologists can get through their work in a reasonable period of time, and the geologists and the mathematicians may be reconciled.

I have here a large globe to represent the earth, and a small globe suspended by a string to represent the moon. At the commencement of the history the two globes were quite close; they were revolving rapidly, and the moon was constantly over the same locality on the primeval earth. I do not know where that locality was; it was probably the part of the earth from which the moon had been detached. No doubt it was somewhere near the equator, but the distinction of land and water had not then arisen. Around the primeval earth the moon revolved in three hours; the earth also revolved in three hours, so that the moon constantly remained over the red region. This I can illustrate by holding the small globe which represents the moon in one hand, and making the large globe, which represents the earth, revolve by the other.

This state of things formed what is known as unstable dynamical equilibrium. It could not last. Either the moon must fall back again on the earth, and be reabsorbed into its mass, or the moon must commence to move away from the earth. Which of these two courses was the moon to take? The case is analogous to that of a needle balanced on its point. The needle must fall some way, but what is to decide whether it shall fall to the right or to the left? I do not know what decided the moon, but what the decision was is perfectly plain. The fact that the moon exists shows that it did not return to the earth, but that the moon adopted the other course, and commenced its outward journey.

As the moon recedes, the period which it requires for a journey round the earth increases also. Initially that period was but three hours, and it has increased up until our present month of 656 hours.

The rotation of the earth has been modified by the retreat of the moon. Directly the moon began to retreat the earth was no longer under an obligation to keep the same face thereto. When the moon was at a certain distance the earth made two rotations for every revolution that the moon made. Thus as I carry the small globe round the large globe the latter makes two revolutions for one revolution of the small globe. Still the moon gets further and further away, until the earth performs three, four, or more rotations for each of the moon's revolutions. Do not infer that the rate of the earth's rotation is increasing; the contrary is the fact. The earth's rotation is getting slower, and so is that of the moon; but the retardation of the moon is much greater than that of the earth. Even though the rotation of the earth is much more than the primitive three hours, yet that of the moon has increased to several times the rotation of the earth.

The moon recedes still further and further, and at length a noticeable epoch is reached, to which I must call attention. At that epoch the moon is so far out that its revolution takes twenty-nine times as long as the rotation of the earth. The month was then twenty-nine times the day. The duration of the day was less than the present twenty-four hours, but I do not believe it was very much less. The time we are speaking of is not very remote, perhaps only a very few million years ago. The month was then in the zenith of its glory. The month was never twenty nine times as long as the day before. It has never been twenty-nine times as long as the day since. It will never be twenty-nine times as long as the day again.

Resuming our history, we find the moon still continuing to revolve in an ever-widening circle, the length of the month and of the day both inreasing. The ratio of the day to the month was still undergoing a change. When the moon was a little further off the earth only revolved twenty-eight times instead of twenty-nine times in one revolution of the moon. Still the velocity of the earth abates until it only makes twenty-seven revolutions in one revolution of the moon. This is an epoch of special interest, for it is the present time. In the present order of things the moon revolves round the earth once while the earth rotates twenty-seven times. This has remained sensibly true for thousands of years, and no doubt will remain sensibly true for thousands of years to come, but it will not remain true indefinitely. Wondrous as are the changes which have occurred in times past, not less wondrous are the changes which are to occur in time to come. The tides have guided our gropings into the past; they will continue to guide our researches to make a forecast of the future.

Further and further will the moon retreat, and more and more slowly will the earth revolve. But we shall not pause at intervening stages; we shall try to sketch the ultimate type to which our system tends. In the dim future, many millions of years distant, the final stage will be approached. As this stage draws nigh, the rotation of the earth will again approach to equality with the revolution of the moon. From the present month of twenty-seven days we shall pass to a month of twenty-six days, of twenty-five days, and so on, until eventually we shall reach a month of two days, and lastly a month of one day. When this state has been attained the earth will constantly turn the same region toward the moon. I do not know what is the locality on the earth which is destined for this distinction.

Here you see that the first state and the last state of the earth-moon history are in one sense identical. In each case the same face of the earth is constantly directed toward the moon. In another way, how different are the first stage and the last! At the beginning the day and the month were both equal, and they were each three hours. At the end the day and the month will be again equal, but they will each be 1,400 hours. The moon will then go round the earth in 1,400 hours, while the earth will rotate on its axis in the same time. In other words, the day is destined in the very remote future to become as long as fifty-seven of our days. This epoch will assuredly come if the universe lasts long enough. When it has come it will endure for countless ages. It would endure for ever if the earth and the moon could be isolated from all external interference.

Our remote posterity will have a night 700 hours long, and when the sun rises in the morning 700 hours more will elapse before he can set. This they will find a most suitable and agreeable arrangement. They will look back on our short periods of rest and short periods of work with mingled curiosity and pity. Perhaps they will even have exhibitions of eccentric individuals able to sleep for eight hours, work for eight hours, and play for eight hours. They will look on such curiosities in the same way as we look on the man who undertakes to walk a thousand miles in a thousand hours.

For an overwhelming proof of tidal efficiency I shall summon the heavens themselves to witness, and I shall point to the stupendous task which tides have already accomplished. As the moon has made and is making tides on the earth, so the earth once raised tides on the moon. These tides have ceased for ages; their work is done; but they have raised a monument in the moon to testify to the tidal sufferings which the moon has undergone. To that monument I now confidently appeal. The moon being much smaller than the earth, the tides on the moon produced by the earth must have been many times as great as the tides on our earth produced by the moon. It matters not that the moon now contains no liquid ocean. Nor does it matter whether the moon ever had a liquid ocean. In very ancient days the moon was hot the hard, rigid mass which it now appears. Time was when the volcanoes raged on the moon with a fury which nothing on our earth at present can parallel. The moon was then in a soft or a more or less fluid condition, and in this viscous mass the earth produced great tides.

Great tides in truth they were, for the earth is eighty times as heavy as the moon. On the other hand, the moon is only one-fourth the diameter of the earth; so that the actual height of the tides on the moon would be still many times as great as the tides on the earth. When the moon was nearer to us, as it was in early ages, those tides were still greater. Think for one moment of what a lunar tidal wave of such magnitude would be capable. This wave is perhaps of molten lava; it would tear over the surface with terrific power, and anything that friction could accomplish that great current would do. That tidal current has done its work; even if the moon were fluid at the present day it could no longer be distracted by tides. Remember, it is not the mere presence of the tide which produces friction. It is the action of the tide in rising and in falling which accomplishes the work. If, therefore, the moon moved so that it was always high tide at the same place, the tides could produce no further effect. The spot where the tide is high on the moon is the spot which is toward the earth. It hence follows that the action of the tides will cease when the moon constantly directs the same face to the earth. The moon has thus at length gained a haven of rest from a tidal point of view. No doubt the moon has a high tide and it has a low tide, but those tides no longer ebb and flow: The moon has succumbed to the incessant action of friction, and has assumed the only attitude which can relieve it from incessant disturbance.

For many centuries it had been an enigma to astronomers why the moon should always turn the same face to the earth. It could be shown that there were many million chances to one in favor of this being due to some physical cause. The ordinary theory of gravitation failed to explain the cause. Every one had noticed this phenomenon. Yet the explanation was never given till lately. It was Helmholtz who showed that this was a consequence of ancient tides, and this simple and most satisfactory explanation has been universally accepted. The constant face of the moon is a living testimony to the power of the tides. What tides have accomplished on the moon is an earnest of what tides will accomplish on the earth.

In the great conflict of the tides the earth has already conquered the moon, and forced the moon to render perpetual homage as a token of submission. Remember, however, that the earth is large, and the moon is small. Yet small though the moon is, it gallantly struggles on. "You have forced me," cries the moon to the earth, "to abandon the rotation with which I was originally endowed; you have compelled me to rotate in the manner you have dictated. I will have my revenge. It is true I am weak, but I am unrelenting; day by day I am exhausting you by the tides with which I make you throb. The time will assuredly come, though it may not be for millions of years, when you shall be forced to make a compromise. When that compromise is made, the turmoils of the tides will cease; our mutual movements will be adjusted. With equal dignity we shall each rotate around the other; with equal dignity we shall each constantly bend the same face to the other."

THE CAUSES OF VOLCANIC ACTION.*

By PROFESSOR J. PRESTWICH, University of Oxford.

THE hypothesis generally accepted in this country as to the cause of volcanic action is that of the late Mr. Poulett Scrope, who considered that "the rise of lava in a volcanic vent is occasioned by the expansion of volumes of high-pressure steam, generated in a mass of liquefied and heated matter within or beneath the eruptive orifice," and that the expulsion of the lava is effected solely by high-pressure steam generated at great depths, but at what depths is not mentioned, nor is it explained how the water is introduced, whether from the surface, or whether from water in original combination with the basic magma. The objections to this hypothesis are: 1. That during the most powerful explosions, *i. e.*, when the discharge of steam is at its maximum, the escape of lava is frequently at its minimum. 2. That streams of lava often flow with little disengagement of steam, and are generally greatest after the force of the first violent explosion is expended. 3. That it is not a mere boiling over, in which case, after the escape of the active agent—the water—and the expulsion of such portion of the obstructing medium, the lava, as became entangled with it, the remaining lava would subside in the vent to a depth corresponding to the quantity of lava ejected; but the level of the lava, *cæteris paribus*, remains the same during successive eruptions.

Of the important part played by water in volcanic eruptions there can be no doubt, but instead of considering it as the primary, the author views it as a secondary cause in volcanic eruptions. All agree in describing ordinary volcanic eruptions as generally accompanied or preceded by shocks or earthquakes of a minor or local character, to which succeed paroxysmal explosions, during which vast quantities of stones, scoriæ, and ashes, together with volumes of steam, are projected from the crater. The first paroxysms are the most violent, and they gradually decrease and then cease altogether. The flow of lava, on the other hand, which commences sooner or later after the first explosions, is continued and prolonged independently. Ultimately the volcano returns to a state of repose, which may last a few months, or many years. Adopting the theory of an original igneous nucleus, the author considers a certain fluidity of the former and mobility of the latter. The one and the other feebly represent conditions of which the phenomena

* From a paper read before the British Association.

of the rocks afford clearer and stronger evidence as we go back in geological time.

Although thermometrical experiments of the necessary accuracy and length of time are yet wanting, it has been estimated that a small quantity of central heat still reaches the surface and is lost by radiation into space, and the escape of liquid lava and steam from volcanoes, and of hot springs from these and other sources, must bring, in however small a quantity, a certain increment of heat from the interior to the surface, where it is lost. This should lead to a certain contraction at depths, and of readjustment of the external crust, in consequence of which the fused masses of the interior will from time to time tend to be forced outwards whenever tension became sufficient to overcome resistance. In this the author agrees with many other geologists. The former hypothesis respecting volcanic action, he now suggests, he has been mainly led to form by his researches on underground waters. A portion of the rain falling on the surface not only of permeable and fissured sedimentary strata, but also of fissured and creviced crystalline and other rocks, passes below ground, and is there transmitted as far down as the permeable rocks range, or as the fissures in the rocks extend, unless some counteracting causes intervene. Those causes are the occurrence of impermeable rocks, faults, and heat. The former two are exceptional, the latter constant. The increase of temperature with depth being 1° F. for every fifty to sixty feet, the boiling-point of water would be reached at a depth of about 10,000 feet, but owing to the pressure of the superincumbent rocks, it has been estimated that water will retain its liquidity and continue to circulate freely to far greater depths.

Unfortunately, very little is known of the substrata of volcanoes. Etna and Hecla apparently stand on permeable tertiary strata, Vesuvius on tertiary and cretaceous strata, while in South America some of the volcanoes are seemingly situated among paleozoic and crystalline rocks. Under ordinary circumstances all the permeable strata and all fissured rocks become charged with water up to the level of the lowest point of escape on the surface, or if there should be an escape in the sea bed, then to that level, *plus* a difference caused by friction. The extreme porosity of lavas is well known. All the water falling on the surface of Etna and Vesuvius (except where the rocks are decomposed and a surface soil formed) disappears at once, passing into the fissures and cavities formed by the contraction of the lava in cooling. Not only are these fissures filled, but the water lodges in the main duct itself, and occasionally rises to a height to fill the crater. Beneath the mass of fragmentary and cavernous volcanic materials forming the volcano lies the original compact mass of sedimentary strata, etc.

Owing to the fortunate circumstance of an artesian well having been sunk at Naples, we know the underlying sedimentary strata there to consist of alternating strata of marl, sands, and sandstones, some water-bearing, others impermeable. The water from the lowest spring reached in this boring rose at first eight feet above the surface and eighty-one feet above the sea-level. Where the strata crop out in the sea-bed, the same pressure of the column of inland water forces the fresh water outward, so as to form a fresh-water spring in the sea, as at Spezzia and elsewhere on the Mediterranean coast. It is this fundamental hydrostatic principle which keeps wells in islands, and in shores adjacent to the sea, free from salt water, as in the Isle of Thanet. Where, however, the head of inland waters is small or impeded, sea-water will enter the permeable strata, and spoil the springs, as in the case of the Lower Tertiary sands at Ostend, and the Lower Greensand at Calais, and in the Somme, in which latter department the underground spring was found affected to a distance of about one mile from the sea, but pure at a distance of nine miles. Further, if where the head of inland water is sufficient to force back the sea-water under ordinary conditions, those ordinary conditions are disturbed by pumping to an extent that lowers the line of water-level to below that of the sea-level, then the sea-water will flow inwards until an equilibrium is established. The flow of water under a volcanic mountain may be also influenced by the quaquaversal dip, which there is some evidence that the underlying strata there take, owing, probably, to the removal of matter from below, and the weight of the mountain.

If we are to assume that the volcanic ashes and tufas below Naples are subaerial, the original land surface has sunk not less than 665 feet, and a dip of the underlying strata, from the seaward, as well as from inland, has in all probability been caused. This artesian well was carried to the depth of 1,524 feet, and passed through three water bearing beds—one in the volcanic ashes, the second in the sub-Apennine beds, and the third in the Cretaceous strata at the bottom. No eruption of lava can then take place without coming in contact with these underground waters. The first to be affected will be the water in the cavities of the mountain in and around the crater. As the pressure of the ascending column of lava splits the crust formed subsequently to the previous eruption, the water finds its way to the heated surface, and leads to explosions more or less violent. When the fluid lava breaks more completely through the old crust, and the mountain is fissured by the force and pressure of the ascending column, the whole body of water stored in the mountain successively flows in upon the heated lava, and is at once flashed off into steam. Then takes place those more violent detonations and explosions—those deluges of rain arising from the condensed steam—with which the great eruptions usually commence.

In conclusion, the author conceives that the first cause of volcanic action is the welling up of the lava in consequence of presure due to slight contraction of a portion of the earth's crust. Secondly, the fluid lava, coming into contact with water stored in the crevices of the masses of lava and ashes forming the volcano, the water is at once flashed into steam, giving rise to powerful detonations and explosions. Thirdly, there follows an influx of water from the underlying sedimentary or other strata lying at greater depths into the ducts of the volcano; and, lastly, as these subterranean bodies of water are thus converted into steam and expelled, the exhausted strata then serve as a channel to an influx of sea-water into the volcano. A point is finally reached when, owing to the cessation of the powerful shocks and vibrations, and the excessive drainage of the strata, the flow of the lava is effected quietly, and so continues until another equilibrium is established and the lava ceases to escape.

HOLLOW STEEL SHAFTING IN FRANCE.—Hollow steel shafting is being introduced into France. It is made by casting the metal around a core of lime, the ingot being finally rolled into shafting, the lime core going with it and diminishing in diameter in the same proportion as the metal, even when the total diameter is reduced as low as one-fourth of an inch.

VOLTAIC ACCUMULATION.*

WE owe the term voltaic accumulation to M. Planté; we owe the idea of voltaic accumulation to him also. But more than this—we owe to Planté the rich results of a life devoted almost entirely to researches in connection with this subject. M. Planté employs the phrase voltaic accumulation in a double sense—to signify storage, and to signify cumulative effect. It is in this last sense that the term is generally used by M. Planté, and it is to voltaic accumulation in this sense that M. Planté has chiefly directed his attention. One of his principal aims has been to produce by means of voltaic accumulation the high tension effects usually obtained from the frictional electrical machine.

When the platinum terminals of a voltaic battery composed of a few cells are made to dip in acid water, gas in torrents pours upward from them. If the same platinum poles, dipping in the same acid solution, be disconnected from the quietly but powerfully working battery, and put in connection with the prime conductor and the cushion of a large electrical machine of the frictional type, you may turn the handle by the hour and produce an amount of electricity that would maintain a continuous stream of fire, and yet not a single bubble of gas will rise from the poles. M. Planté makes a few cells—two are sufficient—do the work of charging secondary cells, which, after being charged, are joined in series and made to develop high tension effects. This is chiefly the kind of accumulation performed by M. Planté by means of his secondary cell, namely, the accumulation of tension or electromotive force. The Planté cell consists of two plates of lead rolled together, but separated by narrow strips of gutta percha. These two lead plates being, to begin with, in the same condition, generate no current when immersed in dilute acid and united through the wire of a galvanometer. But if the couple be for a time connected, the one plate with the anode and the other with the cathode, of a voltaic cell, or any other form of electrical generator capable of developing an electromotive force of not less than three volts, the anode plate becomes coated with peroxide of lead. If, then, the secondary cell be detached from the primary cells it will be found to be capable of generating a powerful current of about one-fifth more electromotive force than Grove's cell. When it is desired to obtain cumulative effects from a series of Planté's cells a mechanical arrangement is made whereby the plates of the different cells are so connected together that they are in effect one couple; that is to say, all the inner plates are connected together as one plate, and all the other plates are connected together as one plate. Arranged in this manner, if one of the poles of two Grove cells, coupled in series, be connected with the terminal which is common to all the inner plates, and the other pole be connected to the terminal common to all the outer plates, the same change takes place in the 100 or it may be the 1,000 cells as that which takes place in charging a single cell. That is to say, if all the outer plates were connected with the positive pole of the Grove cell, all these plates would be oxidized, and in this condition all the cells may be said to be charged just as a Grove cell is charged when one puts the nitric acid into it; for the highly oxidized lead of a Planté cell plays exactly the same part as the nitric acid of a Grove cell, and it is also necessary to alter the connection of one cell with another, so as to connect them in series, in order to obtain from them the cumulative electromotive effect due to their number.

Planté has devised a convenient method of making this change in the connections. This apparatus illustrates the arrangement. The cells are arranged in line with a spring projecting upward from each plate on each side of the line; between these two lines of springs an axle of ebonite runs, with metal bands so inlaid upon it that, when it is in one position, all the springs on one side are pressing against a long strip of copper on that side, and all the other springs on a corresponding long strip of copper on the other side. In this position the cells are arranged for charging, the two long strips of copper being the two poles. When charging has been effected it suffices to turn the ebonite bar on its axis through a quarter of a circle in order to disconnect the springs from the two long strips of metal mentioned, and to bring them into contact with short strips of copper inlaid and insulated in the bar and crossing it obliquely so as to put the oxidized or positive plate of one cell in metallic communication with the non-oxidized plate of the next cell throughout the entire series. The change of connections is the work of a moment, and the result is a multiplication of the electromotive force by the number of the cells.

M. Planté went a step beyond this. He charged a large series of plates of mica, partly coated on each side with tin foil, on the principle of the Leyden jar. These were connected in charging and in discharging in the same manner as the secondary battery, that is, all the coatings of tin foil turned one way were connected together, and all the coatings turned the other way were connected together. When, by the momentary joining of these two groups of plate coatings to the two poles of 800 secondary cells, the plates became charged, the connections were then changed from quantity to tension. By this contrivance the electromotive force of the four volts, due to the two primary Grove cells, was accumulated first to 1,800 volts, and this again was increased fifty-fold by the mica plates. I can bear witness to the fact that it was sufficient to produce flashing discharges some inches in length, exactly resembling the discharges of a frictional electrical machine. That is electrical accumulation in one sense, but there is another sense in which the phrase has been much used of late in connection with Faure's accumulator, namely, in the sense of storage. Planté's cell, with slight modifications, lends itself most perfectly to voltaic accumulation in the sense of storage. The very essence of the idea of storage is retentivity. The cell, to act as a reservoir or store, must be retentive of the charge communicated to it. This is a quality possessed in an eminent degree by the Planté cell. There is, comparatively with other voltaic cells which, but for the want of retentivity, might be employed for electrical storage, very little loss of charge by lapse of time within the limit of a few hours. But for the defect of loss of charge by local action—that is, chemical action not utilizable in the production of electric currents, the zinc and copper cell of Daniell and several other well-known voltaic combinations not usually regarded as susceptible of being used as secondary cells might have been employed for electrical storage. Perhaps the ideal of a cell for storage is Grove's gas cell. Here is a specimen of it; it consists of two gas tubes, and two plates of platinized platinum immersed in dilute sulphuric acid. If, while the tubes are filled with dilute acid, one plate is connected with the positive and the other with the negative pole of a voltaic battery, the one tube becomes filled with oxygen and the other with hydrogen, and when so filled the cell is an electric store, capable, even after the lapse of a long time, of yielding a current. But Grove's cell is quite out of the question for large operations, if only because platinum is so scarce. Theoretically it would perhaps be improved by making the hydrogen pole of palladium instead of platinum, so as to obtain the advantage of greater condensation of the hydrogen, and thus to reduce the resistance by increasing the extent of the contact between the gases, the pole plates, and the acidified water. Dr. C. W. Siemens communicated to the York meeting of the British Association some interesting experiments in the employment of plates of carbon, both simple and platinized, as substitutes for platinum plates in the construction of a gas battery. The porosity of the carbon plates was utilized so as to bring the poles close together and greatly reduce resistance. The results obtained were well worthy of publication, although they did not quite reach the point aimed at, namely, practical utility for the electrical storage of energy. For electrical storage on any large scale we look in vain to discover a better material than that fixed upon after infinite painstaking by M. Planté. Planté's cell, pure and simple, is a most admirable electrical accumulator in the storage sense of the word. It has one drawback, however. it requires a considerable time to give to the lead plates a large storage capacity. M. Planté's method of preparing his cell is as follows:

The secondary cell is first filled with water acidulated with sulphuric acid—one quart acid to ten quarts of water—and on the first day it is charged by the current from two Bunsen cells six or eight times, the direction of the primary current being changed at each new charge. The secondary cell is discharged between each reversal of the direction, and it is ascertained either by heating a piece of platinum wire to incandescence, or by other suitable means, that the duration of the secondary current continually increases after each charge. The time during which the secondary couple is submitted to the action of the primary current in the same direction is increased little by little. Thus, on the first day the period is increased from a quarter of an hour to half an hour, and one hour; and, finally, the battery is left overnight in the process of charging. The next day it is discharged, and then recharged for two hours in the opposite direction, then again in the previous one, and so on. But soon a limit is reached, beyond which the duration of the secondary current is not found sensibly to increase, especially when the primary cells, not having been removed, have grown by these successive actions little by little weaker, and have no longer sufficient intensity to cause the electrolysis to penetrate deeper into the interior of the lead plates. The secondary couple is then left at rest for eight days, and at the end of that time is recharged in the opposite direction for several hours continuously, without making on that day a fresh alteration in the direction of the primary current. Then the interval of rest is extended little by little to a fortnight, one month, two months, etc., and the duration of the discharge is found to go on continually increasing. It has, in fact, no other limit than the thickness of the lead plates. The positive plate if it is thin, finishes by being almost entirely transformed by time into peroxide of lead of a crystalline texture; and the negative plate becomes formed by degrees, to a certain depth below its surface, of reduced lead of a granular and crystalline nature. It is not always necessary to push the electro-chemical preparations of secondary couples as far as this complete transformation of the physical and chemical nature of the plates, for the couples would ultimately acquire a much greater resistance and take more time to charge them. When the couples yield a current of sufficient duration for the purposes for which one wants them, it is no longer necessary to change the direction of the primary current each time the cells are charged. The quantity of peroxide of lead accumulated upon the positive plate would take too long to reduce, and no result would be got from the couple before several hours. A definite direction is therefore adopted, in which the secondary cells, when once sufficiently "formed," are always charged.

It is evidently desirable—more especially in view of the want more and more urgently felt as time goes on, of an accumulator which will be available for the large and important uses to which electricity will in future time be put—if possible to avoid this tedious process of preparation so minutely described by M. Planté. No doubt it answers the purpose quite well when industrial applications are not in question, but for electrical accumulators such as must be used in connection with a central system of electric lighting, and which would probably involve the use of a set of large cells in every house, this slow process of preparation would be hardly applicable. It was with a desire to avoid this disadvantage and give to Planté's cells a greater capacity of storage that I made the experiments last winter, the outcome of which was the modification of Planté's cell, which I showed you at our February meeting. Here are some of the cells I then exhibited in action. The idea of this modification was to increase the surface of the lead by means of lead foil, crimped and formed into frills, the interstices between the frillings being filled with electrolytically deposited spongy lead. The same idea has been applied in a somewhat different way by M. Faure in his accumulator. In M. Faure's accumulator red lead, mixed with dilute sulphuric acid, is plastered on lead plates, the coated plates are wrapped in felt, and either rolled up like the plates of a Planté cell or doubled together and placed in rectangular lead-lined wooden boxes. These cells have been made on a large scale, and for this reason, and because the application of the red lead coating greatly favors the obtaining of storage capacity effects have been obtained from them clearly pointing to practical use in electric lighting, and perhaps also for other purposes. The cell has, of course, the same electromotive force as the Planté cell, of which it is a modification; being large, it has, when fully charged, a small resistance, and is, on that account, capable of producing astonishing effects in the way of heating thick wire. [Heats some wire]. Thirty of these cells, weighing about fifty pounds each, when properly charged, will keep twenty of my lamps up to twenty candles power for several hours. M. de Meritens has also made an accumulator on the Planté lines.

I have recently introduced into the construction of the Planté cell some modification which, I anticipate, will increase its utility when applied on a large scale for the practical work of storage for electric lighting. One of my innovations consists in making the lead plates corrugated or cellular, the cells or grooves being filled with spongy lead, which from the form of the plate will remain attached to it without any external wrapping of felt or similar material being necessary. The felt in the Faure cell must, I imagine, be in a short space of time destroyed by the action of the acid, and occasion displacement of the material applied to the surface of the plate and held in its position by it. I have heard that it is proposed to substitute asbestos cloth for the felt; this no doubt will remedy the defect I have

* Abstract of a paper read by Mr. Swan before the Newcastle Chemical Society.

mentioned, but it must greatly increase the cost of constructing the cell. It is obviously desirable to avoid the use of any extraneous material, and the use of grooves or cellular plates accomplishes this object. I have made other improvements for the means of obtaining electrical storage, details of which I must for the present hold in reserve, but with the hope at some future time of bringing them under the notice of the society.

SOME OBSERVATIONS OF MR. HOLTZ ON INDUCTION MACHINES.

OWING to very long sparks having been recently obtained with ordinary induction machines by several experimenters (particularly by Messrs. J. & H. Berge), Mr. Holtz has been

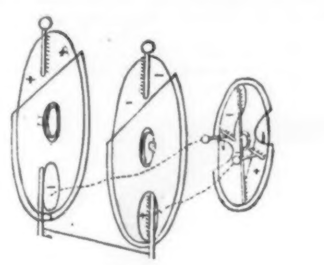


FIG. 1

led to describe a special arrangement designed to effect a like result.

Although Mr. Holtz has already indicated such an arrangement he has not been in a position to carry out the idea; and he now points it out as a means that must assuredly give the results anticipated, and urges those who can do so to construct an apparatus on this plan.

Fig. 1 is a theoretical diagram of the arrangement. The

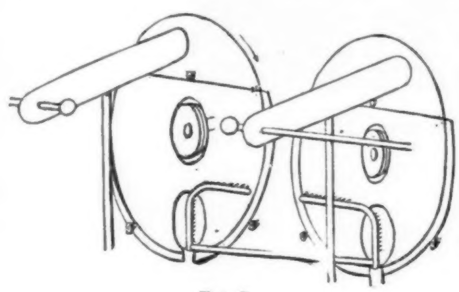


FIG. 2.

two circular stationary plates, which correspond with the two external movable ones, have their upper portion removed on a horizontal line. At this lower part they carry two armatures, which are charged by the two poles of an auxiliary induction machine. In front of these two armatures there are two combs connected by a metallic rod and constituting the charging conductor. Two other combs are connected with the discharging conductor. To avoid

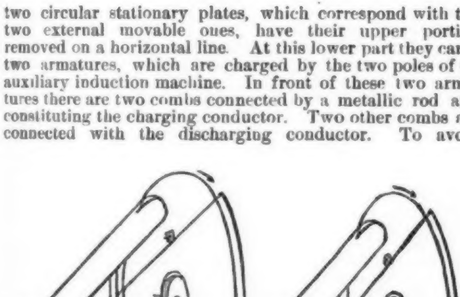


FIG. 3.

stoppages of action or reversals, it is necessary to have still another conductor corresponding with the diametral conductor of ordinary machines and in front of the charging conductor. The two charging combs can, if desired, be connected as shown in the figure, or else be put in communication with the earth. The same is the case with the auxiliary combs.

Figs. 2 and 3 show how the preceding arrangement might

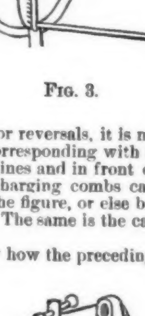


FIG. 4.

be applied on a large scale. In the former of these, the plates are arranged in the same plane, and to the axles of the movable ones (which pass through the fixed) are affixed pulleys which are made to revolve in contrary directions by means of a single winch and a double-channeled pulley. The discharging conductors, without combs, are placed in front of the movable plate; and, at each side, the comb of the discharging conductor and that of the auxiliary conductor are connected by one and the same arched piece.

In the second arrangement (Fig. 2) the plates are in different planes, but parallel. The axle of the winch, situated at a certain distance off, carries two pulleys which are the same distance apart as are the two belonging to the movable plates, and which cause the latter to revolve in the same direction through the medium of cords. In this arrangement the movable plates pass through a slit in the conductors, and the charging combs and those of the auxiliary conductor, arranged as in the former case, are located between the plates. The auxiliary machine may, in such an arrangement, be placed at any point whatever quite distant from the apparatus, but the connecting wires must be well insulated.

For supporting the axles of the revolving plates Mr. Holtz recommends a sort of tripod with glass legs (Fig. 4), and the

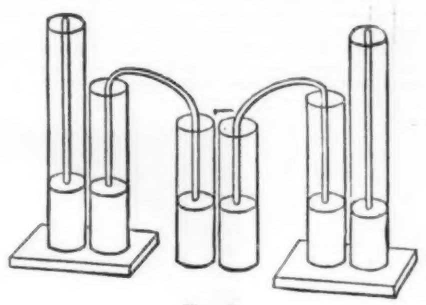


FIG. 5.

upper part of which is, with the exception of the bearings, of ebonite. To the apex of one of these latter there is affixed a small piece designed for holding the top of the stationary plate. For obtaining long sparks the conductor should be constructed in a peculiar manner. Mr. Holtz recommends the use of six jars of the relative dimensions shown in Fig. 5, and connected with each other as there represented. The two end jars should be insulated on plates of glass or ebonite.

The author indicates still another arrangement, such as shown in Fig. 6, where a single rectangular plate is substituted for the two stationary ones, and which is placed in front of the two movable plates and carries two armatures that end in two long cardboard points terminating at two windows. These armatures are covered by another glass plate, which likewise contains two windows corresponding with those in the other plates. The charging conductor consists of two combs connected by a rod which traverses the two stationary plates. The larger comb serves for charging the movable plates, and the smaller one for charging the plate that carries the armatures. This arrangement appears simpler than the two former, but Mr. Holtz considers it less practical.

Mr. Holtz has also studied out a special arrangement of induction machines, from another point of view. To the machines constructed on the principle employed by Tœpler he attaches a simple arrangement in which the stationary plate, provided with two armatures of wide surface, is placed in front of a revolving disk, upon which there act only the two combs connected by the discharger. This arrangement is shown at B in Fig. 7, with the difference that here the fixed plate is circular and in a single piece, while in the Tœpler apparatus it is quadrangular and formed of two separate parts. When an electrified body is brought near one of the armatures of the apparatus thus arranged, the machine becomes primed and begins to operate; but the flow of electricity continually changes direction, even when the discharger is closed; and, in order that the action may continue, the conductors must not be removed further off than a few millimeters. This is an arrangement without practical value, but one that is interesting from a theoretical point of view, inasmuch as it gives place to a continuous action without the revolving disk communicating any charge to the armatures. Mr. Holtz explains this action as due to a separation of electricities in the armatures, and which is effected in the following manner: The movable plate, revolving in the direction of the arrow (Fig. 7, B), acts more strongly, through induction, on the beginning of the armatures than on their opposite extremity. The plate acts less strongly on the latter, because at this moment its action is

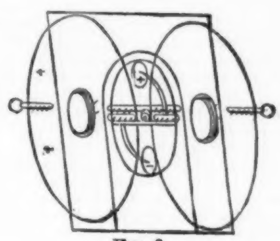


FIG. 6.

likewise exerted on the combs, or else because on approaching this point it keeps continually losing its charge. The electricities of the armatures thus become separated. The electricity of a nature contrary to that with which the movable disk is charged betakes itself to the beginning of the armature; and the extremity of the latter becomes charged as a consequence of reverse electricity, the effect of which is to change the direction of the movable disk's charge. If this charge is stronger than the former, the machine is in a desirable condition for operating in a continuous manner.

Mr. Holtz has made a certain number of experiments to determine whether this separation of electricities really takes place, and also to find out whether the operation of the machine depends solely on such separation, or whether there is also a charge produced in consequence of a flow of electricity toward the neighboring parts of the glass plate. On another hand, he has sought to solve the question as to whether the change of poles is a secondary action, or one of prime importance and necessary to the continuous operation of the apparatus. By first increasing the extent of the armatures until they reached a distance of 5 to 10 millimeters apart, the author found that the quantity of electricity furnished was increased, but at the same time that the tension was diminished. And yet the machine ceased to work only when the armatures were brought close up together.

The armatures were then divided into two parts, which were connected by a narrow strip of tin foil and placed in the two opposite positions shown at A and C of Fig. 7. The arrangement, A, was ascertained to be the better, but in neither case was the operation of the machine interrupted.

Mr. Holtz afterward reduced the armatures to a very narrow T-shaped band (D), and in this case the effect was totally changed, there being no longer any reversal of

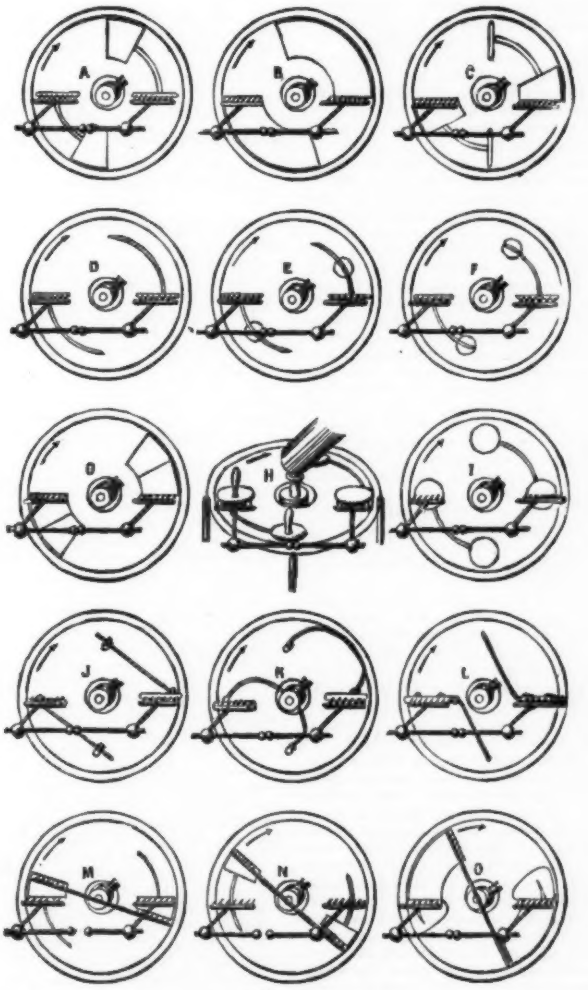


FIG. 7.

direction, and action ceasing at the expiration of from 10 to 12 seconds.

A disk of tinned paper was then added to each armature, either in the position E or the position F, and in both cases the reversals again took place, and the apparatus worked continuously.

Mr. Holtz concludes from these experiments that the change of poles depends not on the form, but on the extent of the armatures; that the rapidity of the reversals depends on the form of the armatures; and that it is maximum in the position F.

In order to discover whether the rapidity of the polar changes depends on the extent of the armatures, he employed interchangeable armatures of two sizes, as shown at G. On making these of tinned paper the result was the same with the two sizes; but on making use of plain paper, the larger armatures gave changes of direction half less rapidly than the smaller ones.

As regards the separation of the electricities of the armatures, the electric state of the latter was studied by the author by means of proof planes. With armatures arranged as at G, he found the electric charge to be of the same direction at the beginning of each armature, but much weaker there than at the opposite extremity of the armature. With arrangement I, on the contrary, the proof planes almost always indicated reverse electrizations at the two extremities of the same armatures. On arranging the horizontal plates as at H, and forming the armatures of two movable plates with an insulating sleeve, connected by a narrow strip of tinned paper, the author was enabled, at a given moment, to quickly remove the two plates of the same armature and study their charges. The result was found to be the same as in the preceding experiment. The separation of electricities in the armatures is thus found confirmed by these experiments, but the latter shows in addition that the separation takes place not only in the direction of the length, but also in that of the thickness of the armatures. The separation in the last-named direction, then, must render the separation in the direction of the length less complete.

In order to discover whether there would result therefrom any change in the operation of the machine, Mr. Holtz first compared the arrangements, H and I, when the reversals were found to be as rapid in the one case as in the other, although the quantity and intensity obtained were greater with the flat armatures than with the thick plates. With armatures formed of a bow-shaped wire (shown at K) the effect obtained was better when the bow was short than when it was long.

It now remained to know whether the flow of electricity above mentioned really takes place. To ascertain this Mr. Holtz substituted metallic wires (arrangement J) for the paper armatures, and observed in darkness the electric flux at their extremities. The reversals then took place at intervals of 45 seconds on an average, while with the armatures before described they took place every two seconds. The duration of the periods was lessened by inclosing the extremity of the wires in a glass tube. The author afterwards entirely inclosed in tubes not only the wire but also that part of the armature corresponding to the comb (see L). There were then no longer any reversals, and action ceased at the end of a short time. Upon opening the extremity of the tubes which inclosed the wires, the reversals again made their appearance, but at quite long intervals.

As for the cause of the reversals of the poles, the author thinks it must reside in the polarization of the inner surface of the plate; but this question he does not decide in a positive manner. Making use in each case of arrangement B, he finally studied the effect of the diametral conductor. With arrangement M, he was enabled to separate the branches of the discharger from each other without interrupting the operation of the apparatus; but, on bringing the rods close together again, the machine ceased action after a short time. With arrangement N, on the contrary, the machine operated whatever was the position of the discharger. In both cases the armatures are T-shaped, but in the former the combs of the discharger and diametral conductor correspond with the wide surfaces, while in the latter the combs of the diametral conductor alone correspond therewith. In the former case, the discharger cannot be closed at will, because the separation of the two electricities would then take place toward the two conductors in a different manner; but in the latter, the principal conductor has no perceptible influence on the separation.

If we refer now to the ordinary machine with windows (shown at O), we see that here the diametral conductor is much more distant from the principal one than in the cases which precede, and yet this presents no inconvenience, since in this case the separation of electricities is only an accessory phenomenon, and one which does not determine the operation of the machine. But, for all that, this is not to say that in this case also the separation is not reproduced, but merely that the separation of electricities exerts no influence, the armatures being incessantly charged during the operation of the machine by means of the cardboard points of the windows.—*La Lumière Electrique.*

COMPARATIVE TOXICITY OF METALS.

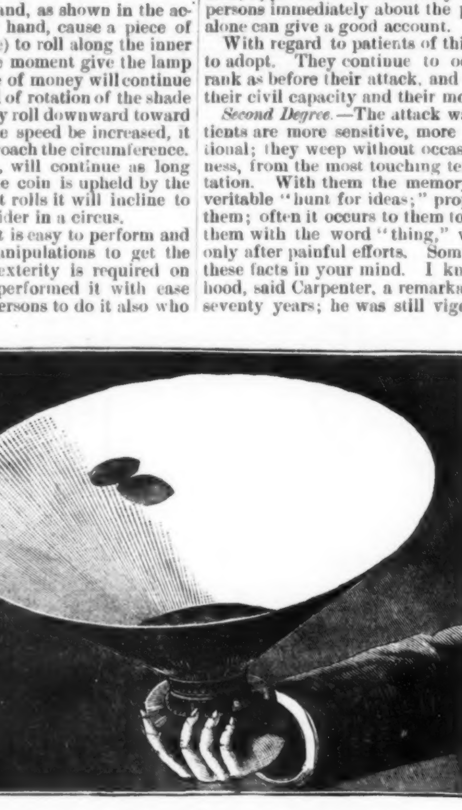
AT the last meeting of the Académie des Sciences (Oct. 24), M. Ch. Richet read a paper in which he gave the results of his observations on the comparative *toxicity* of different metals. If a fish, he remarked, be placed in a toxic solution, it dies with a rapidity which depends on the greater or less concentration of the poison. The author gives as the limit of toxicity the maximum quantity of the poison dissolved in a liter of water, which allows the fish to live for forty-eight hours. Thus, the limit of toxicity for lithium chloride lies between 3 grammes and 2·6 grammes, or 2·8 grammes. He has by this means determined the limit of toxicity of various metals, taking care to employ in all instances the same acid radical (chlorides). He gives a table with a *résumé* of his researches. The limit of toxicity has been calculated not for the weight of chlorine, but for the weight of the metal combined with the chlorine, and always in relation to a liter of water. This table shows that there is no precise relation between the atomic weight of a body and its toxicity. Copper is 600 times more toxic than strontium, notwithstanding that its atomic weight is less. Lithium, the atomic weight of which is but a twentieth of the weight of barium, is yet three times more poisonous. Even in the case of metals of the same chemical family, no relation exists between atomic weight and toxicity. Thus, cadmium (atomic weight 112) is just half as poisonous as zinc (65). Lithium, with an atomic weight of 17, is 70 times more poisonous than sodium. Hence it appears that there is no relation between the chemical function of a body and its toxic power. In fact, potassium and sodium, the properties of which are so similar, are very unequally poisonous, one gramme of potassium being nearly 250 times more poisonous than one gramme of sodium.—*Lancet.*

PHYSICS WITHOUT APPARATUS.

EXPERIMENT ON CENTRIFUGAL FORCE.

TAKE a lamp shade in the left hand, as shown in the accompanying cut, and, with the right hand, cause a piece of money (a ten cent piece, for example) to roll along the inner surface of the cone. At the same moment give the lamp shade a rotary motion, and the piece of money will continue to roll without falling. If the speed of rotation of the shade be diminished the coin will gradually roll downward toward the bottom of the cone; but, if the speed be increased, it will ascend again and gradually approach the circumference. The motion of the coin, once begun, will continue as long as the lamp shade is revolved. The coin is upheld by the action of centrifugal force, and as it rolls it will incline to one side just as does a bare-backed rider in a circus.

The experiment here pointed out is easy to perform and requires but a few preliminary manipulations to get the coin started. No great amount of dexterity is required on the part of the operator. We have performed it with ease ourselves and have caused other persons to do it also who have little familiarity with games necessitating manual dexterity.



EXPERIMENT IN CENTRIFUGAL FORCE.

In the absence of a lamp shade, a hand-basin or a salad bowl may be employed; but a cardboard lamp shade is the object with which the experiment may be most successfully performed.—*La Nature.*

APOPLECTICS.*

THEIR MENTAL STATE, THEIR DEGREE OF RESPONSIBILITY, AND THEIR CIVIL CAPACITY.

Translated for the *Alienist and Neurologist* by E. M. NELSON, M.D., St. Louis.

I DESIRE in a word, to serve you as a guide in a clinical and medico-legal excursion, undertaken amid difficulties, real and often unforeseen, in the practice of our art. Our first session will be devoted to the study of the mental state of apoplectics.

[He calls attention to the fact that the so-called apoplectic habit has no necessary or even frequent relation to the occurrence of apoplexy. He places in the list of "apoplectics" all those who have had one or more strokes of apoplexy. He mentions the characteristic symptoms of apoplexy, with its sequelæ of more or less impairment of intelligence, sensibility, and motility, according as the hemorrhage is more or less extensive, or occupies this or that situation in the brain.]

I should note, in the first place, that the degree of intelligence in apoplectics varies according as you consider such or such another patient. In fact, apoplexy does not necessarily bring on dementia, and it will be a grievous error to affirm the irresponsibility or civil incapacity of an individual for the single fact that he has been previously struck with apoplexy. Just as the troubles of motility and sensation are very different according to the cases, as their degree is proportioned to the extent or site of the cerebral lesion, just so, according as that lesion shall be more or less important, as it shall be localized in this or that part of the brain, as it shall be single or multiple, sometimes the intelligence will survive the attack of apoplexy, almost unimpaired; sometimes, on the contrary, it will be greatly disturbed; and sometimes completely abolished.

It is necessary also to form a sort of classification of apoplectics, a little artificial, I well know, as are all classifications, but which will permit us to study at a glance, at once, the totality of intellectual troubles in these patients, and the peculiarities of each group. I had believed that we should admit three different degrees of perturbation in the understanding of apoplectics; but I have since recognized, with J. Falret, that it would be possible to describe four:

First Degree.—There are apoplectics (and they are more numerous than is generally thought) who, in spite of a characteristic hemiplegia, present, as it were, no appreciable alteration of their mental faculties. A chief of clinic of Prof. Rostau, although struck with a hemorrhage, has been able, during twenty or twenty-five years, to remain one of the most distinguished writers of the medical press. We have seen magistrates, after an attack of apoplexy, resume their functions and continue them with regularity, without anything in them betraying, to a superficial examination at least, any intellectual disorder.

It is not to be said, however, that the understanding in these patients remained perfectly unaffected. The illustrious Prof. Lordat, of Montpellier, being affected with cerebral softening, was able to resume his course, but he had lost his brilliant faculty of improvization, and was reduced to the necessity of reading his lectures.

The character is modified, the will is ordinarily weakened. These apoplectics have become more easy to govern, to control, to terrify, to influence, although more irritable. But these modifications of intellect exist in a degree so little pronounced that a close habit of observation is necessary in order to detect them. To judge these differences, it is necessary to compare what these individuals are with what they were before the attack. It is necessary, moreover, to live constantly with them. The public, and even the physician, appreciate with difficulty those changes of which the persons immediately about the patient, his friends, his wife alone can give a good account.

With regard to patients of this group, there is no measure to adopt. They continue to occupy in society the same rank as before their attack, and we could not place in doubt their civil capacity and their moral responsibility.

Second Degree.—The attack was more profound. The patients are more sensitive, more impressionable, more emotional; they weep without occasion; pass, with a like readiness, from the most touching tenderness to the liveliest irritation. With them the memory is weakened, they make a veritable "hunt for ideas;" proper names and nouns escape them; often it occurs to them to replace the word that fails them with the word "thing," which they sometimes find only after painful efforts. Some typical examples will fix these facts in your mind. I knew intimately in my childhood, said Carpenter, a remarkable savant, aged more than seventy years; he was still vigorous, but his memory was declining. He forgot especially recent facts and words little used. Although he continued to frequent the British Museum, the Royal Society, and the Geological Society, he could no more call them by their names; he designated them by the term *public place.*"*

Winslow has reported the curious fact which follows: M. von B., ambassador to Madrid, then to St. Petersburg, found himself when about to make a visit, obliged to declare his name to the servants. The search being in vain, he addressed himself to his companion: "For the love of God, tell me who I am." The question excited laughter. He insisted, and the visit ended there.

In these patients the will yields still more than the intellect. They lack spontaneity and decision. These men who seem so irritable, so intractable, and are refractory against those who govern them, and revolt against one who attempts to control them; they obey and readily conform themselves to the *role* of passive beings. Their will offers a breach by which it is easy to penetrate.

This degree of intellectual weakness is frequent, and is compatible with the preservation of a great number of correct ideas. Certain of these patients go to their studies or places of employment; they follow their accustomed occupations, and yet their will is so weakened that interested persons can, in the matter of a will, for example, push them to this decision or procure from them such a desired permission. There is here no insanity; there is, again, no dementia; but no more is there a normal state of the intellectual functions.

Third Degree.—There is here a frequent variety of cerebral disorder appearing especially among apoplectics who have had two or more attacks. The patients have lost the notion of the simplest things of life, of the day, of the week, of the place where they are. They forget persons, often those with whom they were formerly most familiar. Louyer-Villermay has reported the case of an old man who, being with his wife, imagined himself to be with a lady to whom he formerly devoted all his evenings, and constantly repeated to her, "Madam, I can not remain any longer; it is necessary that I return at once to my wife and my children."

Judgment in these patients has lost its correctness. There is here veritable insanity, or rather a true dementia. Sometimes delirious conceptions arise; the apoplectics have apprehensions, sudden fears; some one wishes to do them an injury; some one has taken everything from them; some one plunders them; some one persecutes them; they are really unhappy. Sometimes hallucinations appear; terrifying nocturnal visions; a whole phantasmagoric panorama of terrible or bizarre objects passes before the eyes of the patients.

Formerly they were generous, even prodigal. They are to-day parsimonious to a degree which approaches avarice. You see them walking in the streets, generally accompanied by a servant and presenting some signs of semi-maniac excitement; at other times, on the contrary, full of an anxious melancholy, suspicious, distrustful, whining; they complain in a loud voice, repeating in the same tone the same griefs and the same complaints. These are the insane, the demented insane. That is why they are most often placed by their families in the asylums or retreats; a useless measure, for these patients are difficult to watch over and need special care.

Fourth Degree.—We have to do with complete dementia. The decrepitude is complete, intellectual and physical failure absolute; there is degradation and brutishness to its extreme degree. Pass through certain wards of this hospital (La Salpêtrière), and you will see brought together there, I could almost say accumulated, many of these worn-out apoplectics of old date, whose autopsy will soon show the destruction over a large extent (by centers of softening) of the cortical layers of the brain. There remains scarcely anything human to these unfortunates except the external form of the body; the heart still beats, the lungs yet breathe, but all cerebral activity is extinct. Approach these patients, question them; you will have much trouble most frequently,

* Clinical lecture at La Salpêtrière, by M. Legrand du Saulle.

* Carpenter, "*Mental Physiology.*"

I will not say to obtain a reply, but even to fix the attention. Sometimes you will be received with a vacant smile, an uncertain look, an unintelligible grunt. The functions of organic life continue to be exercised, those of the life of relation are almost wholly abolished. An apoplectic singularly resembles a general paralytic arrived at the last phase of his affection. You might be deceived here if you were not enlightened by information derived from the past of this patient. You will be definitely informed by the examination of the lesions which you will find hereafter in the amphitheater, and which you know differ entirely from those which we meet in diffuse meningo-encephalitis. In closing that which relates to intelligence in apoplectics, I ought to call your attention to one interesting peculiarity, which has been brought out by one of my pupils, Dr. De Finance, in an excellent work upon the mental state of aphasic patients. Whatever may be the intellectual weakening in patients who are the subjects of hemorrhage or of softening, there is one aptitude which most frequently is preserved: it is the aptitude for play. These patients, even when memory exists no more, and when intellect is impaired, can follow a game of cards, of dominoes, of checkers, understand the plays, even, to a certain extent, combine and discuss them. Nothing is more curious than the frequent preservation of this faculty in the midst of the general wreck of their understanding.—*Gazette des Hopitaux*, June 14, 1881.

Let us pass in review first the immoral or criminal acts committed by apoplectics, we shall find out what may be, perhaps, the civil capacity of these patients.

1. *Immoral and Criminal Acts.*—I have read, in the course of my life, an immense number of proceedings drawn up by police commissioners of the city of Paris or its suburbs against apoplectics. It is always the same set of facts which are related: such an apoplectic is lost in the street, was unable to regain his residence, sat down upon a bench and slept there; such another has publicly held out his hat to those passing by, and asked alms; this one has urinated on the public way, has exposed his genital organs, or has forgotten to button his pantaloons; that one has raised the skirts of a little girl in open day before the whole world, upon the slope of the fortifications; another, in the *Jardin des Plantes*, has made obscene proposals to a nurse, and offered her two cents to suckle the child in his presence; another has squatted down and evacuated his bowels in a public square; another has made attempts to take obscene liberties with little boys; another has taken three prunes from the stand of a grocer; another has stolen a little saber in a store; another has eaten and drunk in a creamery without having money to pay; another has entered a carriage and had himself driven around for several hours, and he was able neither to remunerate the driver, nor make known his identity; another, having slept two hours in a *café*, could not indicate his address; another readily followed a woman of pleasure and installed himself at her house, and, believing himself at his own residence, would not go away; another alights from a wagon, has lost his ticket, refuses to pay a second time for his seat, becomes insolent and is arrested; finally, another is completely undressed in a public place.

The supposed criminality of an apoplectic is sometimes, moreover, very serious. I remember a very curious case which occurred some years ago. A farm servant, aged thirty-seven years, affected with hemiplegia from a cerebral lesion, who was neither hysterical nor epileptic, became pregnant. She was confined in the night, and the next morning her infant was found dead. She was taken into a court of assizes on charge of infanticide. Acquittal took place because it was easy to demonstrate that, in fact, they were concerned not with a voluntary infanticide, but with an infanticide by omission, the servant not being in a state to take care of her infant.

You will see, after the facts which precede, how important it is to be able to appreciate correctly the degree of responsibility of apoplectics. In the presence of such persons accused, the mission of the judges is not always easy. Magistrates are liable to be too indulgent or too severe. It is upon the physician that devolves the unquestionable duty of casting light upon the question. Now it is evident that your estimate should differ according as you find yourself in the presence of such or such another apoplectic. Refer in your mind to the details into which I entered at the beginning of this lesson. If you have to do with one of those patients whom we have classed in our first, and even in our second group, so that an attentive examination demonstrates to you that the apoplectic possesses a degree of will and reason sufficient so that the act charged was free and conscious, you ought necessarily to admit the responsibility. If it is proved to you, on the contrary, that the intelligence is distinctly diminished, that the will has failed much, but that there still remain, nevertheless, quite precise notions as to good and bad, the just and the unjust, it will be necessary for you to make prevalent the idea of a proportional, that is to say, a modified responsibility. Among these last, in fact, liberty is so limited that we cannot without injustice make them bear the whole responsibility of their faults; it is sufficient that they have to answer in a certain measure for the morality of their acts.

If, finally, the attack was more profound, if unconsciousness was proven, if dementia is positive, you should claim for the apoplectic the benefits of Article 64 of the penal code, which is thus expressed: "There is neither crime nor misdemeanor when the prisoner was in a state of dementia at the time of the act."

2. *Civil Acts.*—If it is important to be able to judge clearly of the mental state of apoplectics in the point of view of the responsibilities which these patients sometimes incur, and the criminal acts or misdemeanors for which they have to answer before the court of assizes or simply before the tribunals of correction, it is no less necessary to know how to appreciate the degree of their capacity in the matter of civil acts. There is a question here which presents itself every day. Let a question arise as to an agreement, to a financial transaction, a guarantee, a marriage, a prohibition, a judicial opinion, a will, you may be asked as to the value of a consent given by an apoplectic, of a signature which he may have affixed, of a contract which he may have concluded.

It is not rare, in fact, that an apoplectic consents to a burdensome agreement. Being well, he had a store, a shop, a manufactory; he carried it on himself, or was assisted by associates or employés. Then the disease came; the attack of apoplexy was produced; then it was that the faculties became weaker and the intelligence diminished. The people who surround him, interested in his affairs, very quickly perceive this failing and hasten too often to experiment upon the situation to the injury of the patient. His associates, for their greater profit, engage in venturesome operations, in which he alone incurs the risks, while they arrange matters in such a way as to share the benefits of the enterprise or of the speculation if it shall be profitable. The physician cannot, to be sure, interfere of himself in cases of this sort; he has not the right, you understand, to set himself as governor or manager of families. But let the patient's wife come to consult him, and this circumstance is not very rare, concerning such an operation or such an agreement which her husband is about to conclude, and it will then be necessary for him to declare his opinion conscientiously.

You ought, in a case of this nature, to have recourse, in order to discharge your whole duty, not only to the attentive examination of the objective symptoms presented by the patient, but also to the elements of information, which I will call, if you wish, extra-medical. Is he concerned in a partnership without sufficient guarantees, in an ill-advised loan, in an unjustifiable removal of capital? It is very probable that your apoplectic, in a state of health and before his attack, would not have complied with these maneuvers, unhandsome, imprudent, and, perhaps, disastrous.

There may present, in practice, questions still more difficult. The patient is alone, without children; he occupies a mansion which came to him from his father; those about him know that it is much easier to appropriate a sum of coin or a bundle of bank bills than to take possession of a piece of real estate. They overreach the proprietor, who opposes too little resistance to the interested counsels which they give him; they persuade him that he ought to sell and make use of good opportunities which offer. In such cases, you will sometimes be called upon to unmask the maneuver, at least to display the wicked projects in giving strong advice. Secure the preservation of the *status in quo.*

About the apoplectic are exercised the worst inclinations, the most criminal plots are woven. It is easy to lead this man, alone, isolated, alarmed as to the future, sometimes abandoned, who sees himself making each day a step toward the grave, to an inappropriate alliance. Shameless speculation is not wanting. It is a mistress, a domestic, who may have had for the patient the slightest but best calculated affection, and will easily succeed in making him marry her, with a contract in good and due form. Here is a fact which recently occurred: An apoplectic was placed in a retreat, with the consent of his family, by a regular process and upon my certificate. Soon an old mistress sent an order from the court which set the patient at liberty. He was immediately taken to a little house, almost inaccessible, situated not far from the fortifications, whence he only went out to the church. On the very threshold he was stricken with a new attack, and died in a few months. In vain did we intervene, five or six physicians and myself, to prevent this marriage; one would not have believed it. At the autopsy, M. Lasègue, G. Bugeron, and myself found old, quite characteristic lesions. So it was that by a criminal stratagem a family has been defrauded of a part of the fortune which should of right come to them.

In the presence of such facts, what ought to be the attitude of the physician? He should not forget the reticence which professional discretion imposes upon him. In no case, is it proper for him to become an informant of his own accord. But I claim that it is sometimes disgraceful that he cannot take certain straight forward, honest, and helpful initiative steps.

Should Apoplectics be "Interdicted?"—To this most grave question, as it is necessary to place the patient under supervision and to suppress his capacity as to civil acts, one could not answer by a simple yes or no. The application, in fact, should be different according to the case.

Do not forget, moreover, that "interdiction" is a measure which it is necessary to use with the greatest reserve, an extreme measure to which it is allowed to have recourse only when the most serious interests of the patient, or the most legitimate ones of his family, are set in peril. So the physician ought to pronounce in favor of "interdiction" only in the case of demonstrated dementia, when the memory is affected without hope of return, and the will is annihilated.

If intelligence is only diminished, if certain faculties persist while others are tottering, if the will is weakened without being destroyed, it would be preferable to have recourse to the giving of a "judicial council" (*un conseil judiciaire*). The "judicial council" is a sort of middle state between the free exercise of all the rights and "interdiction." The individual who is so provided preserves the enjoyment of his effects, the disposal of his revenue, but he is not allowed to alienate his real estate, to invest or withdraw funds, or to contract important engagements without the consent of his "judicial council." He can marry; he can even make a will.

If the apoplectic is placed in a retreat, it will be well to have him name a provisional administrator.

Finally, there are cases where intelligence, in spite of the cerebral lesions, is well preserved, where the faculties are so clear that one can, without inconvenience to the patient, without prejudice to those about him, leave him the free administration of his fortune. It is upon you, you see, upon the estimate that you form, upon the judgment which you formulate, that will depend the taking of such or such measures which I have just indicated with regard to these patients.

I ought, before ending this lesson, to take up one last question: Can an apoplectic make a valid will? Article 901 of the civil code says, "to make a gift during life, or to make a will, it is necessary to be sound in mind." Now, from the details upon which we have heretofore entered, it follows that certain of our patients have surely preserved a sufficient degree of reason to be able to make a will validly; that others, on the contrary, are evidently unfit to do so. Here again is concerned a question of degrees, even of shades, of which you will be the sovereign judges.

Having reached the end of this lesson, which I have shortened at more than one point in order not to overstep the limits which I have assigned myself, I should be happy to have convinced you of the practical interest which exists in knowing well, under its multiple aspects, the intellectual state of the patients whom I have designated "apoplectics." May I have been able to introduce into your minds the thoughts which seem to me indispensable from the standpoint of professional practice each day! These thoughts, no one should ignore to-day, especially, when cerebral pathology has entered upon a new and fruitful way, thanks to important works, many of which have been inspired by the observation of patients placed under treatment in this scientifically celebrated hospital.—*Gazette des Hopitaux*, June 21, 1881.

COLD STORAGE.—The increasing use of cold storage for perishable food stuffs, which are apt to be scarce at certain seasons, is one of the characteristics of the time. Last summer, when fresh eggs were plentiful and cheap, a gentleman in Chenango Co., N. Y., stored in a mammoth cooler some five thousand barrels of eggs. Now they sell in this city as "fresh laid" eggs, at a large profit. As the eggs are removed the cooler is filled up with ducks and other fowl to be sold next spring.

CARE OF THE INSANE.*

By H. WARDNER, M.D., Superintendent of the Illinois Southern Hospital for the Insane.

THE problem of the best care and treatment of the insane is exciting much active thought in the professional and philanthropic mind.

As the result of the following experiment may add something toward the solution of the problem, I offer it as a contribution to that end:

On the 19th of April, 1881, the male department of the Illinois Southern Hospital for the Insane, at Anna, was destroyed by fire. About half-past one o'clock in the morning of that day, two hundred and sixty patients were marched out of the burning building upon the grounds in front, where they were kept until the flames were subdued. They were then crowded into the chapel, center building, and fourth story of the female department, the women in that story being doubled in on the floors below to give necessary room for the men.

About *three men* occupied the space that should be allotted to *one* only. It was evident that these patients could not be kept in this crowded condition during the approaching hot months, pending the reconstruction of the burnt wing, without great injury to both physical and mental health. It was decided to construct temporary quarters for a part of them, and the decision was carried out as speedily as possible.

Within a distance to make it readily accessible to the domestic department of the hospital, a temporary building of one story was erected in the form of a cross, with very long arms, the head and foot of the cross corresponding to the usual center building. Each arm, or wing, is one hundred and fifty feet long, and twenty-eight feet wide. At the end of each wing, furthest from the center building, are six well-ventilated, single or seclusive rooms, for such cases as might be required to be separated from the rest, all the remaining portion of the wing being used as one long dormitory.

A room used for baths, lavatory, and water closet was built out from the rear side of the angle of junction with the center building. The center building is twenty-eight feet wide and one hundred and twenty-two feet long, and is divided into three apartments: an attendant's room, a clothing room, which is also a common connecting hall, and a large common dining room.

At the rear side of each wing is a courtyard one hundred and sixty-four feet long by one hundred and forty feet wide, inclosed by a board fence high enough to prevent the demented patients from wandering from the premises. A door from the wing opening into the courtyard is kept open during the day time, and the patients may pass at will either way. Seventy-five patients were assigned to each wing under the care of four attendants during the day time. During the night one attendant watches the building and all the patients in both wings; the partitions dividing the wings from the center building being constructed of wooden bars with interspaces to admit of the free circulation of air, and give better facilities for oversight.

The patients assigned to these quarters were chronic cases, a considerable portion of them being demented, epileptic, and paralytic.

In noting the results of this forced experiment, we observed that the change was highly pleasing to these afflicted people. A poor demented old man who had been unable to get out of the hospital with the others, exclaimed: "I thank God my foot is on the ground once more."

They delighted in the free, open air of the courtyards, which, by the way, were well shaded with forest trees, and amply furnished with seats. They lost the sickly pallor usually observed among patients kept within walls. The ample space left each man free to exercise in his own peculiar way without infringing upon the privileges of his neighbors; and consequently the irritation and assaults, especially among the epileptic, provoked by limited quarters and personal contact, have been reduced to the minimum.

During the entire season there has been but three or four occasions to use restraint, and those arose from epileptic excitement. These patients have been remarkably healthy during the season, no case of serious disease having originated or developed among them. They have been contented, and the number of escapes have not been more than in previous years.

Sleeping as they have in such large associate dormitories seems to have had the effect to keep them more quiet, and with the exception of occasional excitement from epileptic attacks, there has been no more disturbance than might have occurred had the same number of sane people been lodged in the same room. Those who had previously been noisy and disturbed their neighbors, while occupying single rooms or small dormitories, out of consideration for others, or in consequence of the restraining influence of numbers, and the eye of the night attendant, became quiet and acquired the habit of keeping still, if not of sleeping well. In fact, a general improvement has been observable both in physical and mental conditions.

It was intended to take down this temporary building after a part of the burned wing had been reconstructed and ready for occupancy, and use the material in the rebuilding of the remaining part of the hospital; but its use has proved so satisfactory that it will be retained for temporary use during hot weather, and at times when it becomes desirable to renovate portions of the hospital edifice, if it should not be devoted permanently to the use of the epileptic and feeble patients.

A similar building would, in my opinion, be found of great advantage at every hospital constructed on the ordinary plan, and its occupancy by selected patients during the hot months would prove beneficial, and a great relief from the monotony of the corridor and wards which give to asylum life so much of its prison-like gloom.

The asylum at St. Joseph, Mo., met with a similar misfortune in 1876, which forced upon the management the necessity of providing temporarily for their patients during the reconstruction of the hospital.

In the biennial report of that institution for 1881, the superintendent, Dr. Catlett, asserts that his experience in providing for the insane in cottages and farm dwellings during the reconstruction of the hospital, a period of fourteen months, has in his judgment established the expediency and practicability of providing for all classes of insane in far less expensive dwellings than the model asylum edifice. The doctor notes particularly the beneficial effects of the free out-door life upon the irritable, excitable, and enfeebled patient. He concludes his remarks upon the subject in the following language:

"I extract from the valuable crucible of experience lessons in therapy and provisions for insane, which tend to convince

* Read before the Tri-States Medical Society, October 26, 1881.

me that the model asylum edifice of this era of psychological activity is perhaps erected both at the too great expense of the humane public, as well as opposed to the best hygiene and curative interest of the improved and chronic insane; or, in other words, I am almost persuaded to assert my belief that less expensive segregated cottages, erected on asylum farms for the treatment of the improved and chronic insane, sufficiently near the main edifice where all can be under one supervision, and where exchange of patients may readily be made, when the condition of the patient requires it, would be a very great improvement in the present mode of provision and treatment of the insane.

These experiments having shown such results become strong arguments in favor of a cottage plan, combined with the prevailing system so as to give more freedom and outdoor life, especially to the chronic insane. Such additional facilities need not cost over twenty per cent. of what the usual hospital structures cost the taxpayers of the country, which is on an average about $1,000 per capita. Our building at Anna, which I neglected to state is furnished with hot and cold water, a system of sewerage, and is lighted by gas, cost *thirty-seven* dollars per capita, but is intended for summer use. If such accommodations were added to hospitals already built and in operation, but constructed to meet the emergencies of the winter season, it would result in materially diminishing the cost of maintenance, while the sanitary and hygienic conditions would no doubt be materially improved.

With us at Anna, the result of our experiment has been a strong argument in favor of such a plan, and has largely dispelled the doubts we have entertained as to its utility.

DEGENERATION AND REGENERATION OF SEVERED NERVES.

IN a recent lecture on the functions of the nervous system the venerable Dr. John C. Dalton reviewed at some length the experimental investigations of Waller and Türck. It is forty years, Dr. Dalton said, since the present movement of experimental investigation as to the functions of the nervous system commenced. It had long been a familiar fact that if a nerve was cut the immediate consequence is a suspension of the functions of the section thus separated from the main trunk. If the nerve was motor the muscles supplied by it became palsied; if sensory, there was suspension of sensibility in the parts supplied. But this suspension was not always permanent. Sometimes, after a few days had elapsed, the interrupted function was restored, and this was soon ascertained, by examination, to be due to the uniting of the cut surfaces or ends by granulation and the formation of new fibers. For many years investigation was exclusively directed to the study of the cicatrix and its process; but at length one more curious than the rest extended his studies to the mode of degeneration in the portion of the nerve severed from its trunk, and made some striking revelations, finding that the retrogressive alteration consisted in the granulation of the nervous fibers and the development of fat globules. By experiments on rats it was discovered that section of the sciatic nerve was not only followed by granulation of the fibers, but that when this process was complete the nerve ceased to respond to galvanic stimulation, and had, in fact, lost its functional capacity. A few years later the celebrated Waller, English by birth and education, but for many years resident on the Continent, availed himself of the fact that such degeneration can always be distinguished by microscopic inspection to begin a new method of inquiry as to the anatomy and function of the nervous system, whose results were presented to the Academy of Sciences, France, in a brilliant series of communications. It was Waller who first traced the degeneration that follows section through the whole distribution, availing himself of the extensibility and transparency of the living frog's tongue for this purpose; who discovered that the process of regeneration was by the formation of new fibers, not by the rehabilitation of the old, and who first established the existence of special centers of nutrition. If, for example, the posterior root of a spinal nerve is cut external to the ganglion, the nerve degenerates throughout the whole length of the severed section; if, on the other hand, the section is made interior to the ganglion no such degeneration occurs. In connection with the remarkable experiments of Waller on dogs and cats, Dr. Dalton reviewed the equally important and nearly contemporary discoveries of Türck, of Vienna, who from studies of disease after death had arrived at very similar results. It was the latter who discovered that in some tracts of the nervous system degeneration is propagated from the surface toward the brain (centripetally), while in others the course of the destruction was centrifugal.

DISORDERS OF SLEEP.

By H. POVALL, M.D., Mt. Morris, N. Y.

IN olden times, when there were gods on Olympus, nay, even at an earlier period, before the Titanic divinities fell from their high estate to "wander in vain about bewildered shores," Sleep, the son of Erebus and Nox, gave rest to mortals and gods. Sleep, the brother of Death, dwelt in his dark cave with Dreams around him, and Morpheus as his minister to guard him from noise. Sleep and Death together bore Sarpedon's body to the land of the Lycians; and at the very vestibule and gate of Orcus did the pious Æneas see the same twin brethren seated when he visited Pluto's realm. Sleep was as godlike an agency to the nations of old as death itself. "So like death," says Sir I. Browne, "I dare not trust it without prayers, and a half-adieu unto the world, and take my farewell in a colloquy with God."

What is it? Sleep "which covers a man all over, thoughts and all, like a cloak, that is meat for the hungry, drink for the thirsty, heat for the cold, and cold for the hot."* This sleep, modern observations and researches seem to prove, follows a diminution, both in quantity and rapidity of the circulating blood; and that if this reduced rate of circulation be increased by any cause, sleep departs. The writings and experiments of Mr. Durham, Dr. Jackson, and others, have thrown great light on this subject, and tend strongly to remove all doubt as to this being the true interpretation. Since it is clearly of great importance that we should know what it is that we want to bring about when we are trying to procure sleep, it will be well to examine the theory briefly. The principal evidence as to the state of the human brain in sleep is derived from observations of a woman at Montpellier, a case with which most physicians have become acquainted. She had lost a portion of the skull-cap, and the brain and its membranes were exposed. "When she was in deep or sound sleep, the brain lay in the skull almost motionless; when she was dreaming it became elevated, and when her dreams, which she related on awaking, were vivid or interesting, the brain protruded through the cranial aperture." This condition has also been experimentally brought about and observed in animals, and the same result has been seen, namely, that in sleep the surface of the brain and its membranes became pale, the veins ceased to be distended, and only a few small vessels containing arterial blood were discernible. When the animal was aroused, a blush spread over the brain, which rose through the opening of the bone. The surface became bright red, innumerable vessels, unseen before, were now everywhere discernible, and the blood seemed to be coursing through them very rapidly. The veins, like the arteries, were full and distended, but their difference of color rendered them clearly distinguishable. When the animal was fed and again allowed to sink into repose the blood-vessels gradually resumed their former dimensions and appearance, and the surface of the brain became pale as before. The contrast between the appearance of the brain during its period of functional activity and during its state of repose or sleep was most remarkable."*

* Cervantes.

These observations entirely contradict the theory that sleep is due to pressure from distended veins, to venous congestion; and further experiments made by Mr. Durham proved that when pressure was made upon veins and distention of them produced, the symptoms which followed were not those of sleep, but of torpor, coma, or convulsions.

And this view is completely corroborated by what we know of diseases which are accompanied by these symptoms. Common observation, too, confirms it; we must often have noticed when looking at a person asleep that the face appeared paler than usual, and that a flush came over it on waking; and all are agreed that the circulation is diminished, as also the respiration during sleep. A person in tranquil and natural sleep often breathes so slowly and so gently that we are obliged to listen attentively to discover that he breathes at all.

The disorders of sleep may be divided into four classes: namely, mental, physical, hygienic, and habit.

Mental disorders. The physician regards sleep as the rest, and the only rest, of the brain wherein reside those functions which we call mind. All parts of our bodies rest at one time or another; they cannot always work, but for their rest they need not all sleep. They rest when not in active work, between their work, some more, some less, but the brain proper, that is the higher mental part thereof, rests only in sleep. Healthy sleep presupposes a healthy state of brain, and we must carefully exclude from our notions of sleep all those phenomena which are the result not of healthy but of unhealthy processes going on in the brain, some of which though apparently akin to sleep nevertheless depend on an entirely opposite condition of things. And this brings us to consider what that is which either arouses us from sleep, or repels it, which keeps the brain at work, and hinders its repose. It appears to be a certain strong excitation of that function of the nerve centers, called feeling, whether it be the feeling of emotional excitement, such as the passions or sentiments, or fear of impending disaster, or hopes of good fortune, or the feeling of bodily pain, or even strong sensations of noise or light. All these may be grouped together under the head of feelings, and any one of them, if sufficiently potent, will prevent the access of sleep or banish it from the sleeper. Probably the most frequent cause which keeps awake those who possess neither the happy carelessness of childhood, nor the apathy of old age with its blunted sensibilities, is mental worry, or anxiety of some kind or other. The professional man, whatever his calling, has constantly some important matter on hand, which may turn out well or ill—with an increased or diminished reputation among men—about which he cannot help thinking. Another has been sitting up late at some brain-work, and though, perhaps, he has no great fears about it, yet he has been working hard and long, and he cannot forget it, and shake it off; it haunts him long after he has laid his head on the pillow longing for sleep. Anticipated pleasure, no less than fear, may excite and disturb us and banish sleep. Who does not remember such seasons during his youth and riper years?

Mental emotion quickens the brain circulation. It may be slight or violent, transitory or permanent, but it increases cerebral action. An instant conversion of fear or anxiety into certainty of prosperity or success may sometimes at once bring relief, and from sheer fatigue sleep may follow, but more frequently, the effect of the mental tension is kept up for some considerable time. In short everything which stimulates the brain to a certain amount of action prevents sleep, and this stimulus must be removed before sleep can be obtained.

Not only mental but physical causes also prevent sleep. There may be discomfort of every conceivable kind, from actual violent pain to the malaise of dyspepsia after an indigestible meal, or an uncomfortable position, or an ill-made bed. Most of us have been kept awake by pain of some kind—an aching tooth or a gouty toe. And most of us know the uneasiness attendant upon indigestion and gastric irritation, which though it may not amount to pain, does, nevertheless, by sympathy, react upon the nerve centers, and stimulate them sufficiently to banish sleep. And in the same way hunger, when there is nothing to be digested, will often keep us awake. Cold will prevent sleep; so also will undue heat. In short any irritation of the external senses will prevent sleep, and anything to which the senses are not accustomed will excite them.

Pursuing this point still further, "disorders of sleep" may be due to normal and abnormal conditions of the brain. The brain substance and its membranes may be perfectly free from disease, and yet the rest may be broken and sleep repelled by causes already referred to. These disorders of sleep may, therefore, be called normal. Arising from temporary causes, they excite no alarm as to the future; the causes being removed, the effects soon cease, and balmy sleep returns to bless and refresh the entire system.

But there is a class of disorders much more serious in their results. The advent of these disorders in announced by an invincible tendency to sleep. These disorders cast a pall over the entire system, stealthily but surely stealing a march on the physician who may not have had practical experience in their manifestation. Physical pain may be absent, or so slight as to excite little or no alarm, and yet the natural fount of intelligence, consciousness, and perception may be on the wane. The most acute and powerful intellects among men have thus failed in the noon-time of their being; the brilliancy of genius has been extinguished in youth, just when its possessors had climbed the steps and reached the pinnacle of fame, from causes at first unobserved or little heeded, but nevertheless most potent for evil. Such are plethora, softening of the brain, coma, trance, catalepsy, insensibility from apoplexy, alcohol, and poisons. All these orders may be regarded as abnormal, being due to unhealthy processes going on in the brain.

* Durham on the "Physiology of Sleep," Guy's Hospital Reports, 1860.

"Disorders of sleep" may also be due to defective hygiene. This is especially true of the condition of our crowded cities and towns, where the poor huddle together in small tenements, one room serving in many instances for laundry, cooking, dining, sitting, and sleeping. It is impossible for the occupants of such a place to have refreshing, healthful sleep; with an atmosphere reeking with unwholesome odors and noxious gases. Here the germs of fever are matured, and find in these blanched, attenuated forms a suitable soil in which to multiply and develop. This evil is not confined to large towns and cities. In almost every section of country, old and new, little or no attention is given to proper location, size, and ventilation of our bedrooms. The dining, sitting, and drawing rooms receive the lion's share of attention from architects and proprietors, but the rooms in which we are supposed to spend one-third of our life in health, and in sickness our only abode, are usually miserably small, dark, and without proper ventilation. How can sleep under such adverse circumstances be refreshing or invigorating? How can nature's daily waste be repaired excepting the material required to this end be possessed of all the health-giving elements so amply provided by a beneficent Creator?

Excess of heat and cold are to be avoided if we wish to sleep soundly; bedrooms must be warmed in winter and cooled in summer; people must get rid of the old prejudice about opening bedroom windows, and must eschew feather beds and heaps of spreads and comforters, if they would avoid disordered sleep.

Disorders of sleep may be due to habit. Many persons are habitually bad sleepers, and all know what it is to lie awake and be unable to sleep, even when they are in ordinary health. Nor is it difficult to form the habit. It is an established fact that drinking alcoholic liquors to excess, the use of tobacco, snuff, and opium eating are the result of habit, and even chronic constipation may be brought on by continuously neglecting the calls of nature for evacuation; but in like manner constipation in many instances may be relieved by a daily resort to the closet at a given hour. The habit of insomnia is no more difficult to form than any of these when any of the nervous exciting causes are present to which we have referred in another part of this paper.

The ailments of many persons are due to this habit; the cares and work of the day pursue them far into the night, and when morning dawns, it finds them unrefreshed. Nervous tension continued without intermission, the health gives way, nervous exhaustion ensues, sleep becomes next to impossible. If this condition continues unabated under suitable therapeutic treatment, the end advances with rapid strides.

A class of persons of highly nervous temperament have become so habituated to unrest that their nights are spent in semi consciousness, their days in a tempest of excitement which all about them are made to feel. Can it be wondered at if the stomach fails to discharge its allotted task? if nutrition is ill performed? if a nervous system run at high pressure for years ultimately breaks down in either permanent imbecility or insanity?

Thus we learn that health, happiness, longevity are all more or less dependent on normal sleep, and anything that repels it should be avoided with all our powers, ever remembering the words of the Psalmist, "For so He giveth His beloved sleep."—*Therapeutic Gazette.*

THE BONE-CONDUCTION OF SOUND.

IN the New York *Medical Journal and Obstetrical Review* for February, 1882, Dr. J. A. Andrews, Assistant Surgeon to the Manhattan Eye and Ear Hospital, gives an account of his investigations in regard to the intermittent perception of sound, as conveyed through the cranial bones—the observations having been mostly clinical, largely with the use of the tuning-fork. In order that an explanation for the phenomenon of intermittent bone conduction may be understood, he thus formulates the points in differential diagnosis between an affection of the middle ear and one of the labyrinth, as evidenced by examination with the tuning-fork:

1. If a vibrating tuning-fork, *c*, be placed between the teeth, the hearing power being normal on one side and diminished on the other, and its tone be intensified in the ear of which the hearing power is diminished, the cause is seated in the external or middle ear, and the labyrinth is unaffected.

2. If the hearing power be impaired in both ears, and the sound of the tuning-fork be heard better in the worse ear, and intensified on closure of the ear of which the hearing is most impaired, the cause is still located in the middle ear.

3. If under either of the above-mentioned conditions the vibrations of the tuning-fork be not heard better in that ear of which the hearing power is most impaired, even if its meatus be closed with the finger, and middle-ear disease as a cause can be excluded, there is an affection of the central apparatus of hearing. If the tone of the tuning-fork be still intensified by closure of the ear of which the hearing power is least impaired, there is disease of the central apparatus on one side only. Should the sound of the tuning-fork not be intensified by closure of either ear, then the disease is on both sides, and has its seat in the labyrinth or in the brain.

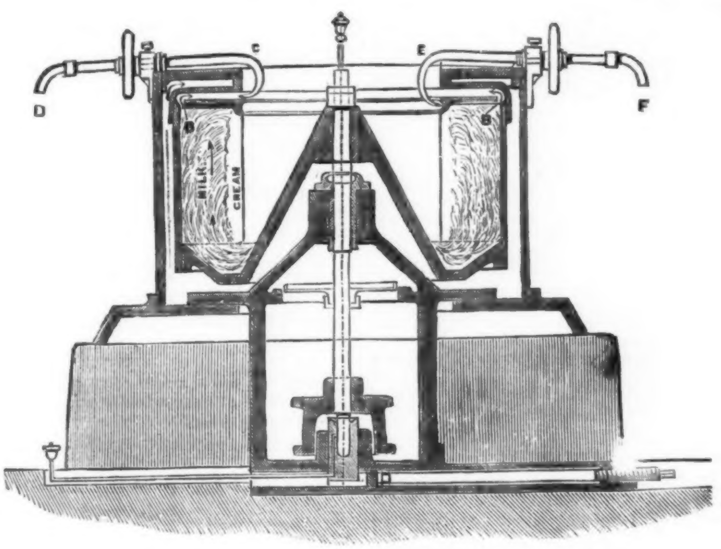
In the first and second propositions the increased resonance results from the reflection of the vibration from the cranial bones upon the nerve. In the third proposition the reflection or condensation of the vibrations of the tuning-fork upon the nerve when the meatus is closed does not intensify their perception, because the function of the auditory nerve itself and not that of the conducting apparatus is impaired. The peculiarity that in some cases of middle-ear disease the watch is not heard by bone conduction, and in other cases examination with the tuning-fork gives the signs of labyrinth disease—*i. e.*, the tuning-fork being heard by bone conduction better in the ear which is normal as to hearing power, therefore diminished instead of increased in the ear of which the hearing capacity is impaired—can not, it seems to him, be explained by assuming an interference with the conduction through the chain of ossicles.

He inclines to the belief, based upon experiments, that this phenomenon is due to increased intra-labyrinthine pressure, brought about in those cases of middle-ear disease in which there is an accumulation of fluid in the tympanum, or the membrana tympani is much depressed, in the former instance by the fluid in the cavity acting upon the oval or round window, or both, and in the latter instance by the plate of the stapes being forced against the membrane in the oval window. In both cases the terminations of the acoustic nerve suffer a mechanical irritation which gives rise on the one hand to subjective noises in the ear, and on the other hand

annuls the perception of certain tones. Extreme pressure upon these parts may so interfere with intra-labyrinthine vibrations as to completely obliterate bone conduction for the tuning-fork.

THE DANISH MILK SEPARATOR.

CONSIDERABLE attention has been given to dairy machinery, and for many years engineers have been endeavoring to devise a machine by which the cream can be separated from the milk by the application of centrifugal force, advantage being taken of the difference in the density of milk and cream. The first machine successful in accompli hing this was made by Lefeldt, but it was a clumsy affair, and did not come into general use owing to the difficulties and disadvantage in working it, as it had to be emptied after the separation of each charge of milk, and refilled. In 1878, a separator, invented by Laval, was brought out; and was first exhibited in England, at the Royal Agricultural Society's Show at Kilburn, in 1879. This was a very ingenious machine, and did its work well. Nevertheless, it possesses disadvantages, the principal being the enormous speed at which it requires to be driven, namely, 5,000 to 6,000 revolutions per minute, thus necessitating constant and careful superintendence. Moreover, the quantity of milk which it is able to separate is said to be small. A decided improvement in this direction appears to be the Danish centrifugal separator which is shown in vertical section in the above engraving. The Aylesbury Dairy Company, of 31 St. Petersburg Place, Bayswater, exhibited one of these separators for the first time in England in the working dairy of the Royal Agricultural Society at Derby, where it was worked side by side with the Laval machine, with the most satisfactory results. The percentage of cream to be removed can be regulated with the greatest exactness, and this separator runs at only 2,000 revolutions per minute. The whole milk is run into the separator from a tank or container. The skimmed milk escapes at B, and is drawn off by the beak and tube, C and D. The cream, when gathered in sufficient thickness, is drawn off by the beak, E, and tube, F. If thin cream be required the cream is drawn off continuously, but if thick cream be required the beak, E, is put into work when desired, that is to say, when the wall of cream is seen to be of sufficient thickness. In this power over the quality of the cream consists one of the most valuable points in this machine. The working of the machine is admirable. Looking into the top of the whirling cylinder, the milk and cream are seen standing up in two distinct white walls around the vessel, and a couple of brass tubes dipping in run off the two products as they collect inside. We may add that the Aylesbury Dairy Company are doing good work in improving the machinery and appliances used in the dairy. They have had charge of the working dairies of the Royal Agricultural Society of England ever since the working dairies were instituted, and they are continually obtaining for trial implements and utensils containing the latest improvements.—*Iron.*



THE DANISH MILK SEPARATOR.

[N. E. FARMER.]

CRANBERRY CULTURE.

THERE are few investments that pay so sure a profit as a well-established cranberry meadow, provided, of cou se, that it is carefully managed by intelligent and experienced hands. It is also a fact that a great deal of money has been wasted in unprofitable attempts to grow cranberries in locations not suited to their needs, and by bad management in places where the natural conditions were good. The natural requisitions for a good cranberry bed are as follows: a peat meadow with a foot or two of black peat, so situated as to its surroundings that it can be drained by open ditches to a depth of about a foot below the surface, and also flooded, during the winter at least, with two feet of water. Another indispensable condition of success is a plenty of clean sharp sand near by, as free as possible from loam and sods.

The chief purpose of flooding is to protect the vines during winter and early spring from frosts; if the vines start too early in spring the blossoms are sometimes blighted by late spring frosts, and it is therefore customary to keep the vines flooded till about the 10th to the 15th of May. If there is sufficient flow of water to flood the meadow in a few hours, during June and October, it is sometimes of great advantage to be able to do so; but there are many good meadows where this cannot be done from insufficient supply of water. The object in flooding in June is to kill the cranberry worm, and in October to protect the ripe berries against frost until the picking is over. Where this can be done it will add very much to the certainty of success, and will be regarded as an important help in the natural conditions, but not absolutely essential to success.

To reclaim a piece of wild meadow and plant it with cranberries is a rather expensive job, costing usually from two to four or five hundred dollars per acre, and since no return can be expected for two or three years, and a full crop not before five years after planting, it is evident that whoever undertakes cranberry culture will need some patience and perseverance as well as the ability to wait for his returns.

The first thing to be done is to dig ditches to carry off the water, at least a foot below the natural surface; the ditches are usually made about thirty or forty feet apart, leaving the meadow in square beds, with a headland ditch running along the edge of the upland to cut off surface water. After cutting the ditches, the sods or bushes are to be entirely removed from the surface to some convenient place of deposit, and either used for a bon-fire or for composting manure. The surface is then to be carefully graded so as to give each bed a slightly rounding surface, sloping toward the ditches. It is then to be covered with clean, sharp sand, to a depth of two or three inches; the deeper the peat the more sand will be required. After raking the sand smoothly off, the young vines are set out in rows about two feet apart each way; this is best done in May. The vines are usually set by hand, using a trowel for the purpose, and scattering two or three cuttings in each place. The plants should be set deeply enough to have their lower part in the peat for an inch or two. They will need hoeing and hand weeding through the summer, for two years, after which they may be expected to keep down all foreign growth by the dense sod they make, and the picking of fruit will usually be pretty good by the third year.

The dam for flooding the meadow is one of the most important and also one of the most troublesome things to maintain in the whole affair. It is very apt to become the home of muskrats, and their burrows are sure to become watercourses and undermine the work when the water is raised for flooding the meadow; the best remedy is to trap them and fill up their holes. The dam must of course be provided with a sluice gate and flash boards, and the frame of the gate must be well packed around with clay puddle.

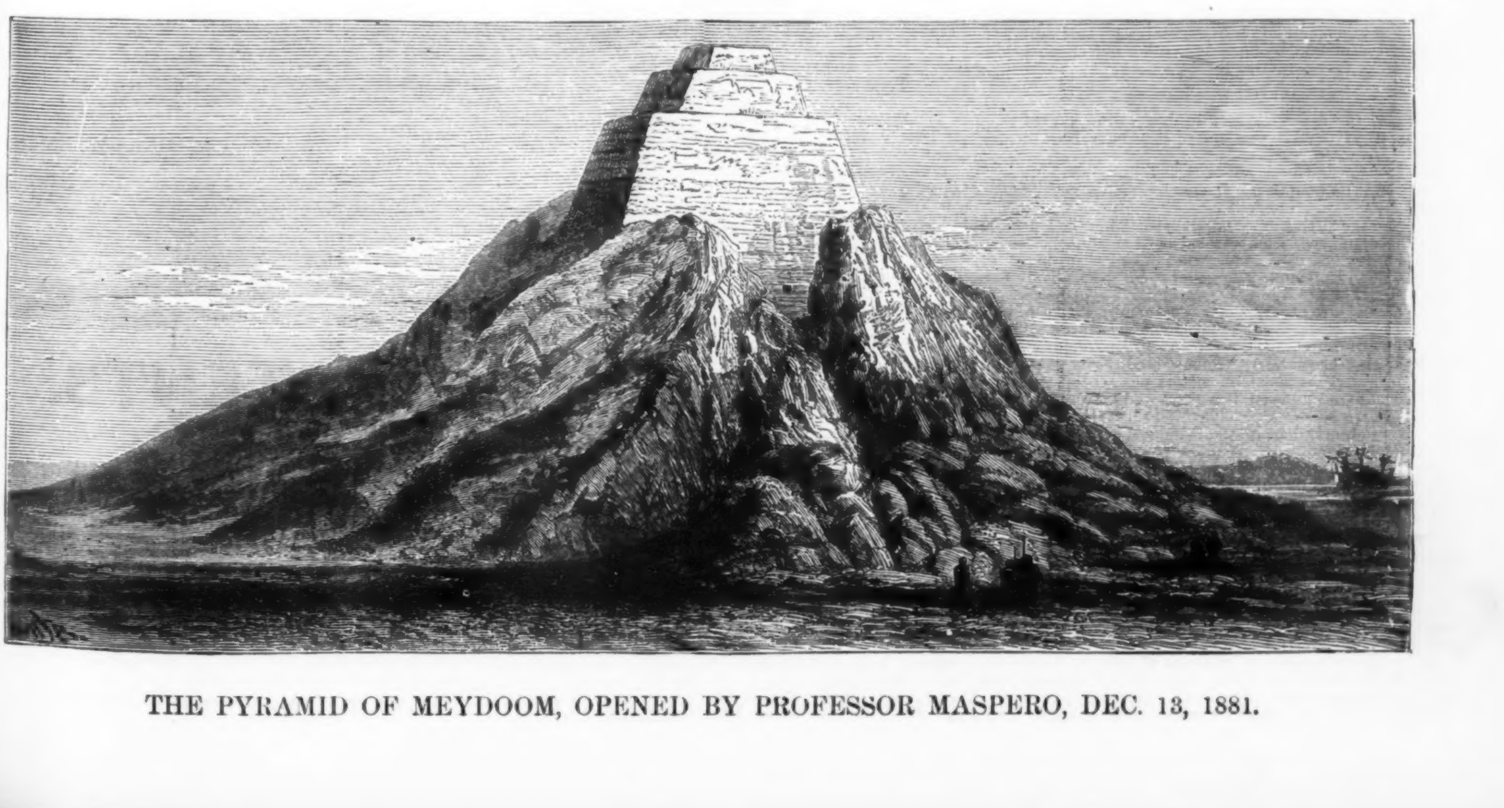
The picking of cranberries for market is best done by hand; the rake sometimes used for the purpose injures a good many berries, and also gathers much chaff, which must be culled out by hand; the rake is chiefly useful on wild meadows where the fruit is scattering and of poor quality. All soft berries are rejected in putting up No 1 fruit, and unripe ones are best sorted out and sold separately. Like most other fruit, much of the success in handling it depends on care and skill in putting it up in clean, well assorted packages. There are several varieties of cranberries in cultivation which are of very different value and size, and any one intending to plant them would be wise to consult some experienced grower, and be sure that he is planting a good kind, and that he is not deceived in buying his stock.

It would seem that the market for this fruit has fully kept pace with the large increase in its culture; the price is now \$8 to \$12 per barrel, and as a good meadow will produce 70 to 100 barrels per acre in good years, with little expense except picking, marketing, and interest on the outlay, it is fair to conclude that with good management there is a large margin for profit in their culture. They are shipped to England in considerable quantities, and it is probable that the market will not be glutted with good cranberries for many years to come.—*W. D. Philbrick.*

THE PYRAMID OF MEYDOOM.

OUR illustration represents the Pyramid of Meydoom, the entrance to which was discovered by Professor G. Maspero, on Tuesday, December 13, 1881. The village, pyramid, and necropolis of Meydoom are situated between thirty-five and forty miles south of Cairo, on the western bank of the Nile, and about four miles inland from the river. The village of Meydoom, built high on a rubbish-mound of unknown antiquity, occupies the site of the ancient city of Metun, and perpetuates its name. The city of Metun is found mentioned in various inscriptions of the Third Dynasty; and the pyramid upon which the attention of travelers and archæologists is at this moment centered, is supposed to be the sepulchre of Seneferoo, the last king of that Dynasty, and the immediate predecessor of Khoofoo (Cheops), first king of the Fourth Dynasty, and builder of the Great Pyramid of Gheezeh. The surrounding Necropolis abounds in tombs of the Third Dynasty, the latest of which are chiefly those of "royal relatives" and nobles of the court of Seneferoo.

As seen from the railway, standing apparently on a lofty hill in the midst of a desert plain, or as seen from the river, rising in solitary gloom against the sunset, this pyramid represents a very imposing and singular appearance. It is built in three superimposed stages, inclining inward (like three truncated pyramids one above the other) at an angle of 74° 10'; and it stands 122 feet above the eminence upon which it seems to be built. The lowest stage measures 69 feet above the mound; the second 20½ feet; the third, which is much ruined and was probably very lofty, about 25 feet. The *revêtement*, or stone facing, consists of Mokattam limestone,



THE PYRAMID OF MEYDOOM, OPENED BY PROFESSOR MASPERO, DEC. 13, 1881.

admirably jointed and polished. It is, in fact, the finest external masonry work remaining upon any pyramid. This pyramid has hitherto been supposed to be unopened. Professor Maspero, however, by cutting a vertical trench down the north side of the hill, has laid bare the face of the pyramid, and proved that it rises direct from the plain. The "hill" is found to be an immense heap of accumulated sand and *débris*, which has probably been formed since the end of the period known as the New Empire. The height of the lower stage is therefore now seen to be about 184 feet. Exactly in the center of this northern face (*i. e.*, about twenty meters above the plain) was discovered an opening about 1 meter 60 c. square, from which a passage of the same dimensions descends at a rapid incline toward some point not yet reached. This passage has already been cleared to a distance of 40 meters. For the first 10 meters it is lined with superb masonry; beyond that point it reaches a central core of rock, and becomes an excavated sloping shaft of the same size, and descending at the same angle as before. The pyramid is, in fact, built around a natural rock, in the heart of which it is presumed the sepulchral chamber will shortly be discovered. At a short distance from the entrance there was formerly a "stopper" stone, the place of which is clearly indicated; but this stone has been destroyed and removed at some very remote period. It is evident that the pyramid had been violated and was open to the curious as early as the period of the Twentieth Dynasty; three *graffiti*, or scribbled inscriptions in the hieratic writing, written by visitors of that time, having been found on the ceiling at the very spot where the closing-stone had originally been placed.

The rapidity with which Professor Maspero has carried out this work is as remarkable as the success with which it has been crowned, the trench not having been begun till the last week in November, 1881. The labor is, however, very trying, owing to the want of air and light, and the overwhelming heat inside the Pyramid. The workmen cannot stay in for more than an hour at a time without fainting, and being carried out to recover.

It is hoped that hieroglyphed inscriptions of great archæological importance may be found in the sepulchral chamber; though doubtless everything in the shape of movable treasure was rifled when the pyramid was first opened.

The date of Seneferoo is estimated by Mariette Pasha at B. C. 4235; and by Brugsch at B. C. 3766.—*London Graphic.*

THE RECENT ERUPTION OF MAUNA LOA.

The flow of lava from this noted Hawaiian volcano, lately in eruption, is the greatest observed there within the last fifty years. It began on November 5, 1880, and continued without interruption till the middle of August, 1881. Probably no lava flow has been so largely photographed, and an artist, M. Furneaux, has represented various phases of it in thirty eight oil paintings. A published letter from Mr. Green, of Honolulu, states that when the lava accumulates on a large surface a permanent cloud of condensed vapor, with smoke, forms above. When the cloud becomes too dense the cooled vapor descends through the hot and light air below, and when the waterspout reaches the incandescent lava it is anew converted into vapor. In such cases there is usually a surface of several square miles of lava at a red heat, and more or less in fusion. Photographs of the lava near Hilo show that after flowing thirty or forty miles it was still in a very liquid state. Further up it has formed the usual scoriaceous embankments, and a tunnel of its cooled crust. Wherever it could be seen through apertures in this crust it seemed as liquid as water, and at a red-white heat. It was apparently a case of pure igneous fusion; no vapor or gas was observable when the stream did not enter water or come on vegetation. Eight photographs were taken of a lake with vertical sides, two miles from Hilo, which was filled with lava in one hour and forty minutes. The pretty little town of Hilo was like to be ingulfed, the lava forming a semicircle of fire about it, and the possibility of damming and diverting the current was being considered, but happily the flow ceased in time, and parts of the arched crust falling in afterward, blocked the passages, so that Hilo at the end of August seemed comparatively safe, at least for some months.—*London Times.*

DESTRUCTIVE FORCES ATTENDING TORNADOES.

Memorandum No. 1.

Prepared for the *American Architect*, by General W. B. Hazen, Chief Signal Officer, U. S. Army.

From the examination of the data contained in the works referred to in memorandum No. 2, it appears that during the passage of a tornado, buildings and other objects are subject to the following destructive forces, viz.:

I.—VELOCITY, OR FORCE OF THE WIND.

1. From the destruction of bridges, wind pressures of from 18 to 27 pounds per square foot have been demonstrated.

2. From the destruction of brick buildings, wind pressures of from 58 to 84 pounds per square foot have been demonstrated.

3. From the lifting up and transportation and destruction of loose objects, such as a barrel of tar, a locomotive, a stove, a heavy log, cattle, etc., wind pressures of 52, 93, 31, 112, and 58 to 83 pounds per square foot respectively have been demonstrated.

4. The upward pressures are occasionally shown to be as great, if not greater, than the horizontal pressures.

5. Downward pressures, or downward movements of the wind have not been clearly demonstrated.

6. Upward velocities of 60 meters per second (135 miles per hour), are not unusual, if we may judge from the effects produced.

7. From observations of the Robinson anemometer, horizontal wind velocities of 80 miles per hour (36 meters per second) have been recorded during tornadoes; subject to a reduction to about 65 miles per hour for possible instrumental errors. But as velocities of 180 miles per hour (reducing as before to 140) have been recorded in hurricanes, there is no apparent reason why the latter should not also be attained in tornadoes.

II.—AREA EXPOSED TO DESTRUCTIVE WINDS.

That the destructive wind velocities previously enumerated are confined to very small areas, such as 10, 20, or 100 feet square, is shown:

1. By the narrowness of the path of greatest destructiveness; the destruction of fences, trees, etc., is frequently visible over a path many miles long, but only a few hundred yards wide; but the path of greatest violence is very much narrower than this. The excessive cases above enumerated are observed only in small isolated spots, less than one hundred feet square, unequally distributed along the central portion of the track; hence in very large buildings, bridges, etc., only a small portion is liable to be subjected to destructive wind in the passage of a storm.

2. In the different portions of this area of maximum severity, the winds are simultaneously blowing from different—perhaps even opposite—directions, so that the total resultant of the winds at any moment is not so much to overturn or carry off or crush in, but rather to twist around a vertical axis—thus trees are found twisted off, and buildings are generally lifted up and turned around immediately before being torn to pieces—numerous instances of this last action are given in the tornadoes investigated by Sergeants Finley and Mackintosh.

3. As the central area of maximum intensity is comparatively narrow, and the chances are very small that a building will be exposed to the violent twisting action, it is evident that the average velocity of rectilinear winds within the general path of moderate destruction is the one most necessary to provide against in ordinary structures. These winds may attain a velocity of 80 miles per hour, over an area 1,000 feet broad, and generally blow from the southwest; those next in frequency blow from the northwest. Of course, the tendency of such a wind upon an object whose center of inertia does not coincide with the center of figure, will be first of all, to turn it around through an arc sufficient to bring these two centers into the line of the direction of the wind, which partial rotation may occur anywhere within the path of the tornado, and is to be distinguished from the destructive twist that is experienced by bodies that lie in the path of maximum intensity. A similar problem occurs in the case of monuments, stones, etc., disturbed by earthquake shocks, as was first pointed out by Mallet.

III.—THE DURATION OF THE EXPOSURE.

1. The time during which an object is exposed to these destructive winds varies from six to sixty seconds—the general average of a large number of cases is sixteen seconds—it is therefore probable that the maximum winds at the tornado center rarely continue longer than the lower of these limits. A building exposed to these winds experiences but one stroke like the blow of a hammer, and the destruction is done. In the case, therefore, of a suspension bridge, a chimney, or other structure liable to be set into a system of rhythmic vibrations, destructive to its integrity, the effect of the maximum winds in inducing such vibrations is reduced to a minimum.

2. The duration of the heavy southwest and northwest winds prevailing over the area of moderate destruction rarely exceeds two minutes.

IV.—VERTICAL WIND CURRENTS.

At the point over which the center of a tornado stands at any moment, or immediately beneath the funnel or spout that is seen descending from the clouds, there is experienced a strong vertical current whose tendency to destroy and carry upward is greatly assisted by a local diminution in the barometric pressure within the funnel, by virtue of which the air previously confined within a dwelling exerts an outward pressure that is not counterbalanced by the exterior atmosphere. The amount of this unbalanced pressure is, as shown by Ferrel, frequently much more than one inch of mercury or a half pound to the square inch, and may easily amount to ten times this quantity. Of course the interval during which this expansive force is exerted is but a few seconds, corresponding to the time occupied by the central spout in passing along its path, which motion of translation is, on the average, at the rate of 30 miles per hour.

The relative frequency of tornadoes during the months of the year is as follows, beginning with the month of greatest frequency: July, May, June, August, April, March, September, February, October, November, January, and December.

The geographical distribution of 247 tornadoes, from 1794 to 1878, was as as follows, viz.:

New York....	24	North Carolina..	7	Connecticut	4
Indiana	20	Alabama	6	Michigan.	4
Illinois	20	Minnesota......	6	New Hampshire	3
Ohio....	16	Mississippi	5	Arizona.........	2
Georgia	16	Maryland.......	5	Louisiana	2
Iowa...........	11	Virginia........	5	Kentucky	2
Kansas..........	11	South Carolina..	5	Rhode Island...	1
Pennsylvania...	10	Massachusetts...	5	Colorado	1
Tennessee	9	New Jersey.....	5	Indian Territory	1
Missouri........	9	Dakota.........	4	Wyoming do.	1
Nebraska.......	8	Wisconsin......	4	Maine..........	1
Texas	8	Florida.........	4	Montana	1
				New Mexico....	1
	162		61		24
Total				247	

Doubtless the irregularity in this geographical distribution is largely due to the imperfection of our fragmentary records.

The distribution with reference to the time of day is about as follows:

Between 11 A.M. and noon	4
" noon and 1 P.M.	2 ?
" 1 P.M. " 2 "	7
" 2 " " 3 "	7
" 3 " " 4 "	5
" 4 " " 5 "	24
" 5 " " 6 "	12
" 6 " " 7 "	7

The remainder are equally distributed at the rate of about two per hour throughout the other hours of the day.

A BIRD-CATCHING SEDGE.

Another example of the wonderful adaptation of seeds for the purpose of distribution is recorded by a writer in the *Gardeners' Chronicle* as having been observed by him in those of the *Uncinia jamaicensis*, a Jamaica sedge. This is a plentifully distributed plant, growing in damp hollows and shaded woods on the Blue Mountains of the above-named island. The plant is about a foot or eighteen inches high, with narrow-pointed, grass-like leaves. The flower-head is a slender spike about three inches long, of a dark brown shining color. Its most remarkable feature, however, consists in the spikelets, which are furnished with a smooth, long-exserted awn of a peculiar hooked character, resembling a shepherd's crook, but with the hook pressing so closely against its base that it will hold the finest hair. By means of this delicate and wonderfully-contrived awn the seeds of the sedge attach themselves with great tenacity to the coats of dogs, the legs of pedestrians, or, indeed, to anything that comes within their reach; and when once they are attached they are removed with the greatest difficulty. In fact, as showing their finely adjusted power and their tenacity, it may be stated that if a spike is drawn along the back of the hand the hooks will clasp and easily pull out single hairs by the roots.

The narrator states that on two occasions he has found small birds (grass-quits) securely caught by a couple of spikes of this sedge. The spikes were attached along the under side of the body of the bird, with the hooked awns buried among the feathers. From the secure manner in which the birds were caught he has no doubt that many birds, not large enough to drag out the spikes, or draw the spikelets from their receptacles, must die in this manner from exhaustion, or fall a prey to rats and other vermin.

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